BLOCKCHAIN ENABLED ASSET MANAGEMENT IN THE CASE OF X-DECKS

Cooperation enhanced by decentralization in the building industry

Keywords: business innovation, blockchain, circularity, transparency, supply chain optimization, building lifecycle, asset management, parking as a service, digital transformation, AEC industry

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[1] *Graphic from title page derived from (ValorisationCentre, 2017)*

Preface

My interest in blockchain technology was sparked by a documentary about Bitcoin in 2016. Back then, I had no clue how it really works but I liked the idea that individuals can run their own currency. With time I learned about the potential and broad application areas of this technology and started to get to know other people who were also interested in this field. From there, it was not long anymore till I decided to start this thesis journey. It was a challenging process to get grip on this IT-heavy topic but there were the right people around me to guide and support me through this process:

First, I met Zhijie who guaranteed me his support although he did not really know where this journey was going. Then, I want to thank Alexander and Peter who challenged my perceptions and gave me guidance when I needed it. And, of course, Teun who had a lot patience with our weekly feedback sessions and who gave me the right connections to broaden my scope with inspiring people like Robijn and the Blockchain 030 group.
It was a pleasure to work in this interdisciplinary team of mentors that made it possible to go new ways and I hope it was an enriching experience for everybody involved.

Ultimately, I want to thank my friends, family and Sara for all the support, love you give and patience you have for me.

Abstract

The building industry is characterized by the creation of organizational silos. These silos are causing frictions and inefficiencies on an operational, financial and managerial level. The following research is approaching these silos within the case of X-Decks, a temporary and circular parking project, and the means of blockchain technology.
The thesis is a contribution to the current theoretical and practical research gap on blockchain technology in the built environment and its potential in in an early adoption phase. By targeting traditional structures in the building and parking industry, it is necessary to innovate current means to develop, construct, manage, operate, maintain and reuse parking buildings. An in-depth evaluation of blockchain technology with potential stakeholders of the X-Decks case is used to derive an asset management framework and blockchain prototype that aim to change traditional hierarchical processes into more coequal and transparent ones.

Contents

Introduction

Problem statement

This thesis research is conducted in close cooperation with Royal Haskoning DHV (RHDHV) that provided the 'X-Decks' case (see: X-Decks – Project Description). Within the boundaries of this case, the research aims to elaborate on a novel approach to connect businesses with each other in a more efficient and transparent way through new technological means. RHDHV made first steps towards a modular construction system in the X-Decks case but the innovation process of the managerial and financial sides is still in its infancy. To be able to create a lasting business model in the parking market, it will be necessary to innovate the whole lifecycle of the X-Decks parking project.

Current frictions in the building industry and the X-Decks project are mainly caused by the creation of organizational silos due to following practices:

- Exposing information about costs and revenues to external stakeholders, can easily turn into competitive disadvantages

- Conservatism and resistance to new technologies and process innovation are common in the building industry

- "Suppliers have information that is critical for effective client decision- making, but are not motivated to fully share that information" (Winch, 2010)

- "Buyers cannot easily monitor the quality of the goods or services received, and so suppliers are tempted to substitute lower quality goods or be less than diligent in the supply of services" (Winch, 2010)

- Construction execution varies in duration, which creates uncertainty. Independent decision makers at the resource-based level **tend to act in their own interests rather than in the interests of the collective**

- "The actors in supply chains have limited trust in each other due to the competitive nature and the presence of confidential data"(El Maouchi, 2018)

- "Inherent in the construction industry is adversarial behaviour, disputes, claims and litigation"(McDermott, 2017)

This results in a black-box mentality that is supporting confidentiality, intransparency and mistrust towards external parties which comes along with an increasing amount of costs for intermediaries, supervision and outsourcing of tasks.
In contradiction to the developments in the building sector, there is an upcoming technology called blockchain that enables new trust models (Androulaki, 2017) :

On January 3, 2009, Satoshi Nakamoto, unleashed the Bitcoin blockchain technology — in the form of the genesis block — as a salve intended to heal the damage caused by ill-managed debt-based fiat currencies, fractional reserve banking and widespread manipulation of nearly all significant global markets by entities that considered themselves too big to fail, or in many cases, too big to need to play by the rules. A string of text was embedded in that block: "The Times 03/Jan/2009 Chancellor on brink of second bailout for banks." Satoshi had an agenda (Nakamoto, 2008).

Not everything that Bitcoin was used for up to today was as genius and selfless as intended but the combination of peer-to-peer networks with public-key cryptography, timestamping of transactions and a distributed consensus is changing the game in the financial sector and slowly beyond that (Mansfield-Devine, 2017).

Regarding the organizational silos mentioned above that stimulate a black-box mentality, blockchain technology brings the possibility to cut out middlemen and create a network of trust between competing or untrustworthy stakeholders by providing an all-over documentation of the business and information flows between the stakeholders on a blockchain network. The decentralization of business and information flows can further result in an increasing efficiency, security and transparency of the building processes**.** Ina blockchain network, transactions of assets, e.g. land, materials or working hours can be exchanged without the need of having intermediates, like banks, involved. Cooperation enabled through decentralization of information and transaction flows is rather new in the building industry, where real estate is heterogeneous and immobile. This is why "buying, selling, and leasing real estate tends to be illiquid, localized and highly segmented" (Dijkstra, 2017). Furthermore, it distinguishes itself from other asset classes by having high transaction costs, strong governmental regulations and a relatively slow adaption to match demand and supply. These characteristics have implications for the overall efficiency of the market.

Combining the business case of RHDHV and the innovation potential of blockchain technology the following problem statement is formulated:

On one hand, organizational silos are common in the building industry, coming along with multiple frictions and inefficiencies. On the other hand, knowledge about blockchain technology in the business cosmos of RHDHV is scarce. In order to create more transparent processes between businesses with emerging technologies, highly different perceptions of potential stakeholders on the value, technological and organizational uncertainties related to the consequences of implementing a blockchain application have to be tackled.

Main findings from literature research

Decentralization means, in the case of blockchain, that a ledger is replicated between all nodes and each node contributes to the maintenance of the ledger. Information is recorded append-only on a blockchain. This secures that transactions cannot be modified once they are added to the blockchain, respectively it can be seen if data is changed retroactively.
A blockchains' main functionality is decentralisation, but companies have different interests and different points of view on the benefits that can come along with decentralisation and set focus on other aspects like transparency, efficiency, security, etc. Hence, it is more important to see the company or case-specific requests to meet the requirements.
A permissioned blockchain is most suitable for the X-Decks case in the starting phase. Since the 'Focus Group' of external stakeholders (Chapter 'Dissemination and audiences') will act in a B2B environment, there is no gain to make data publicly available in the starting phase. Just on a long-term perspective it might be desirable to include the public on the blockchain to make possible the direct distribution of parking fee payments on a blockchain system.

Blockchain opens the door to disrupt any industry that relies on a central authority to confirm authenticity (Friedlmaier, Tumasjan, & Welpe, 2016). It allows independent, and even competing organizations, to share information and gain efficiency on an inter industry-level.

The inter-industry standardization process is probably the lengthiest challenge of adoption at this moment of time.

Societal and scientific relevance

Blockchain technology did not exist ten years ago but is now gaining a lot of attention from multiple industries and academics, even outside of the information technology sector. This technology is graded by many information technology experts and consultancies as highly disruptive. Blockchain is changing the way we use currencies and has the potential to bring game-changing improvements to various sectors (Brennan, 2016; Friedlmaier et al., 2016; Mansfield-Devine, 2017), including the building industry (Cardeira, 2016; Kachmazov, 2017; Lifthrasir, 2016; Ngo, 2016; Spielman, 2016). Use cases of potential blockchain applications are often created without further evaluation of the potential stakeholders. This can be problematic because there are many misconceptions, organizational limitations and critical perspectives about blockchain technology, while cooperation beyond company boarders is crucial for most applications. In this respect, the thesis shall complement current research and literature about blockchain in appliance to the building industry. Further, opportunities and limitations through blockchain are defined for the X-Decks case.
This research is of interest in the current situation: on the one side, blockchain is hyped, on the other side, there is limited insight into actual use cases in the building industry and its impact in this sector.

Research questions

To identify the impact of blockchain technology in the case of X-Decks, the following research objectives are defined:
The aim of this research is to identify the potential of blockchain technology on the case of X-Decks and evaluate the impact of this technology in a tailored framework.
First, blockchain technology will be studied in depth with a literature research. Second, this research aims to evaluate cooperation possibilities with external stakeholders of the X-Decks case and create a blockchain enabled asset management framework with associated recommendations for RHDHV.

The research objective is formulated in one main research question and five supportive sub-questions. The **main research question** states:

> *How can asset management in the supply chain of the X-Decks case be applied to a blockchain enabled asset management framework?*

The supply chain in the X-Decks project will consist of manufacturers that produce assets in form of construction materials, sub-contractors and contractors that assemble and operate the building, investors and RHDHV as a initiator and consultant. The whole lifecycle of the X-Decks project shall be evaluated in this research.
Asset management, as mentioned above is not considered as the management discipline between property and portfolio management (see Chapter “First steps toward organizational innovation”) like defined by (Ad van Driel, 2016) but as a more general term to describe any form of asset transfer (e.g. materials, land, working hours) during the building, operation and disassembly process of the X-Decks project. Since a blockchain enabled asset management framework would turn the management pyramid of (Ad van Driel, 2016) in a more circular model. The operational, tactical and strategic decisions are partly merged into the responsibility of every stakeholder and cannot be clearly separated like by (Ad van Driel, 2016) anymore.

The first sub-question shall provide the necessary theoretical background for blockchain:

1. *What is blockchain and how can it facilitate decentralised utilities?*

Based on a literature review key concepts of blockchain technology are explained and these are set into context with the X-Decks case in the second sub-question:

2. *What are the key features of the blockchain technology in application to the X-Decks case?*

The second question evaluates blockchain technology and its possible key features for the X-Decks project. The technology analysis will elaborate particularly on trust and transparency issues.

3. *What are likely adoption scenarios for blockchain-based trading in the parking industry*?

The third question will use the gathered information from the literature research and case study to create a sequence of possible adaption scenarios for the X-Decks project. Further, a list of key performance indicators will be created to evaluate interviews with potential stakeholders in the X-Decks project (see: Research methods).

4. *What roles can current market parties play in such a system?*

The fourth question is strongly related to the third question but takes the feedback from the interviews into account and will further elaborate on the role of potential stakeholders in the scenarios.

5. *How can different stakeholder attitudes affect the framework?*

The fifth question deals with different perception of the stakeholders, received during the interviews and applies it hypothetically to the asset management framework.

Concluding, this research intends to deliver recommendations to RHDHV on the opportunities and threats brought by blockchain technology to the business to business cosmos of the X-Decks project. Beyond that, more general principles on blockchain technology can change current cooperation models between companies are derived to inspire new business models within the building industry and beyond.
Blockchain can be seen as a mean to improve current supply chain processes and realize economic value (Chesbrough & Rosenbloom, 2002). Therefore**, the inherent value of a technology is latent until it is commercialized**. Considered from another perspective is can be also seen as a driver of organizational changes and according business models (Haaker, Bouwman, Janssen, & de Reuver, 2017). The second perspective would bring a fundamental change that can disrupt whole industries and remove the basis for existing business models!

Research methods

This research has an explorative nature and follows a qualitative approach. It aims to find answers to generate a theoretical framework rather than testing an existing one (Bryman, 2015). Figure 1 illustrates the methodological approaches. The five steps are building upon each other to answer the main research question and sub-questions. A combination of research methods is used here.
First, a literature review about blockchain technology shall help evaluate the current status quo. Second, the resulting information is used to create Key Performance Indicators (KPIs) by merging the fields of this thesis research: blockchain technology and the X-Decks case. These KPIs are used for a better comparison during the further interview analysis. The interviews are conducted to study information and business flows of potential stakeholders in the X-Decks project. Furthermore, the interviews shall help to put blockchain on the map of stakeholders who might have not heard about it and draw their attention to upcoming blockchain enhanced possibilities. In the next step, the creation of a blockchain enabled asset management framework takes place. The feedback of the external stakeholders about the scenarios will be used to refine the framework. Based on the framework, a prototype will be created to show first interaction possibilities with blockchain technology.
Finally, in the last step the results are bundled in conclusions, reflection, answering the main research question and further research possibilities.

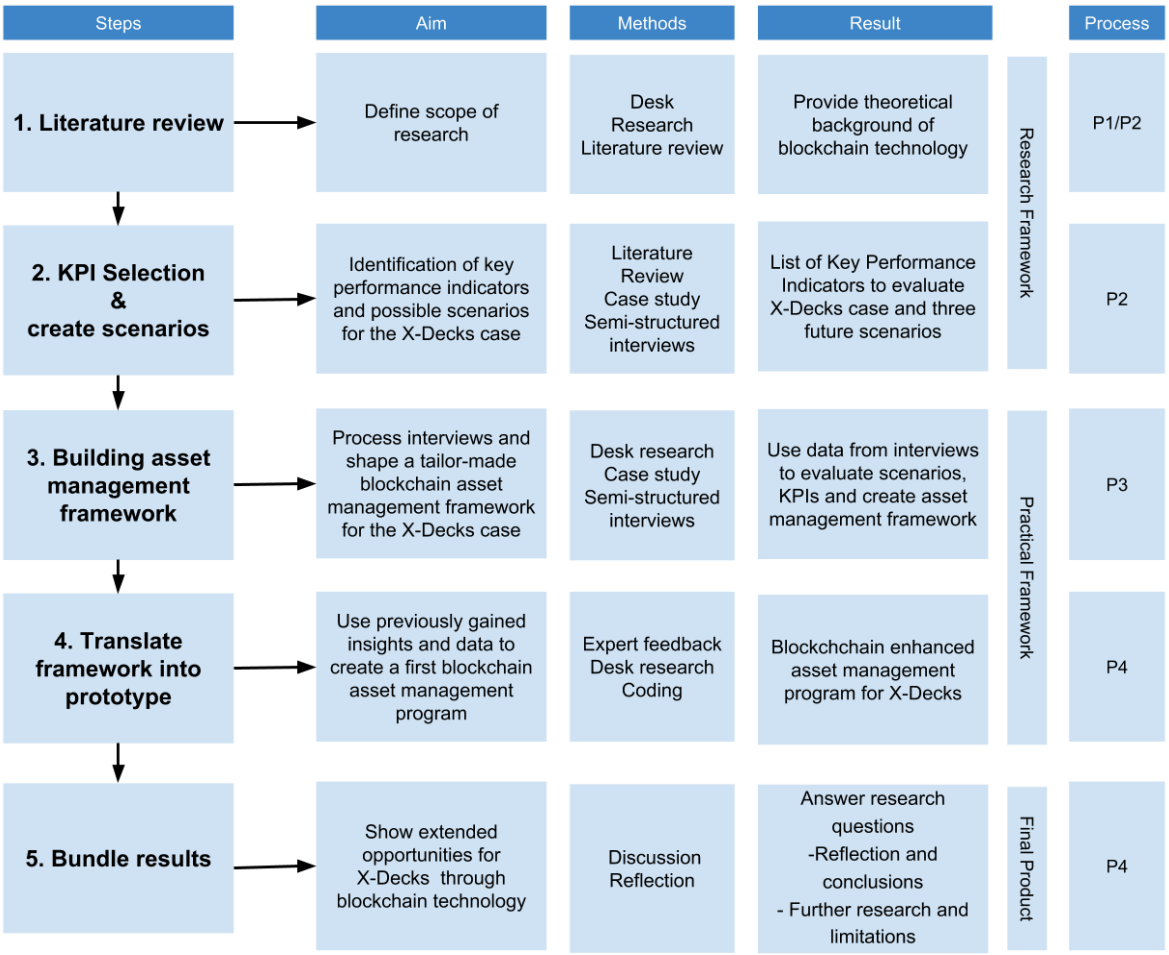


Figure 1. Research methodologies

Data analysis

This research intends to add value to literature in the inference zone of blockchain technology and the built environment. On the one hand, blockchain can be viewed as a mean to create new services and realize economic value (Chesbrough & Rosenbloom, 2002). Therefore, the inherent value of a technology is latent until it is commercialized. On the other hand, blockchain technology can be seen as a change in the business environment that requires companies to adapt their business models (Haaker et al., 2017). Here, a new technology is just one environmental force that affect a company's business model. The Literature and desk research shall help here to balance these two perspectives and give a general overview of blockchain technology as well as in its application potential for the building industry. At the same time, the case study shall help to steer the theoretical research towards a practical output.

Half way through the literature research, the key stakeholders are identified and contacted for semi-structured interviews. The propose of these interviews is to inform the stakeholders about first results from the literature research, study their business and information flows, present the scenarios and define the KPI's towards their interests in the X-Decks project. Semi-structured interviews are chosen because the complex circumstances of informing about blockchain technology, studying their business flows and catching their attention for a possible cooperation requires a combination of agile and arranged methods. The interviews sessions took about one hour.

With the established KPI's that are aligned with the stakeholders' and RHDHV's perceptions, the scenarios were refined in three steps: what is possible now, on a mid-term perspective around 2020 and on a long-term perspective around 2025. The technological as well as the organizational structures of the business to business relationship are respected to create a realistic outlook of blockchain technology in the built environment.
The scenarios are used as a starting position of the blockchain enabled asset management framework, with focus on operational, financial and blockchain related processes between the stakeholders. The framework shall serve as a "Proof of Concept" for a first prototype that implements first processes of the framework.

The final results of this thesis can be used by RHDHV and its external stakeholders to implement a first blockchain enabled pilot project. It shall further lay the foundation for a common starting point to explore blockchain technology in the built environement and beyond.

Research output

Goals and objectives

- Tear down organizational silos through a new organizational approach
- Blockchain deployment: design a framework where information and transactions can be shared in a more transparent way
- Investigate into the external stakeholders' willingness to commit to a blockchain enabled asset management framework;
- Raise awareness and inform the main stakeholders about the potential of blockchain technology: Early adoption benefits and risks, involving a shift of market shares is here the main motivation to participate and align contrasting perceptions
- Size the potential impact of blockchain technology on the X-Decks project
- Strengthen flexible, short-term leasing concept of X-Decks

Deliverables

- In-depth blockchain literature review
- KPI's and scenarios tailored to the X-Decks project
- A blockchain enhanced asset management framework, evaluated through relevant stakeholders for the X-Decks project
- A Blockchain prototype

Dissemination and audiences

This research addresses in first instance professionals rooted in the built environment with interest in future opportunities of digitalization, emerging technologies and business innovation. Beyond that, the framework and prototype are a contribution to blockchain research and potential use cases on an inter-industry level.

The X-Decks specific audience is summarized in Figure 2. The focus of this thesis research is the B2B environment, in particular the RHDHV business cosmos of the X-Decks project, shown as the inner layer 'Focus Group' in Figure 2. It was important to cover a wide variety of stakeholders in the building cycle of the X-Decks case to ensure a horizontal and vertical scalability of the results.

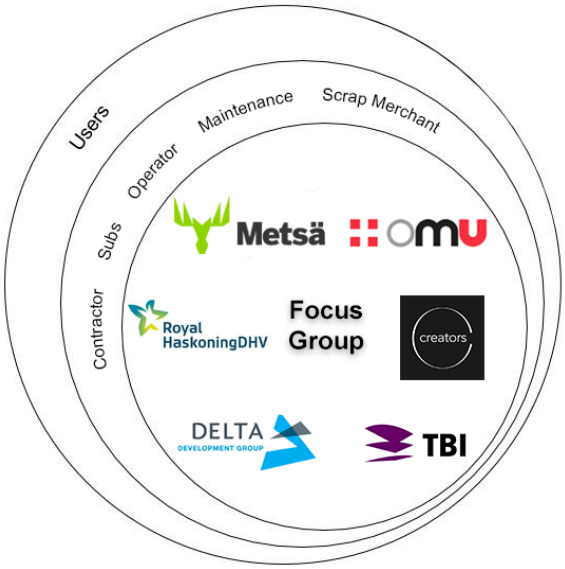


Figure 2. Stakeholders of the X-Decks project (own illustration)

Personal study targets

The aim was to deepen my business and information technology knowledge for the implementation possibilities of blockchain technology. Further, preparing myself for a more digitalized and automated working environment where the incorporation of new technologies will play a key role to stay competitive and stay tuned with game-changing technologies that will occur in higher frequencies in the future.

Furthermore, I am curious to see how decentralized application will empower individuals when services like Uber, Airbnb or Facebook can be run without a central authority but only by the computational resource of users, like in the Bitcoin network. This also got me interested in programming and I am working on a basic skill set to implement my findings in a first blockchain prototype.

X-Decks – Project Description

The simple typology of a flexible parking structure shows unexpected possibilities when considered in more detail as well as in the broader context of the building industry. The following project description shall give an overview of the innovation potential of the X-Decks case. From its predecessor to changing currently common processes in the building industry, working towards more circular and transparent processes and accessing new business segment, this chapter shall show all facets of the X-Decks case.
Furthermore, giving an introduction of the X-Decks project shall help to consider further research into blockchain technology in direct relation to this case study.

Parking as a service
In an increasingly connected and dynamic world, there is a growing demand for adaptable and demountable parking solutions. Shared and self-driving vehicles might lower the need for parking spaces in future and current urban planning regulations are already pushing towards this direction (see: "Transcription Interview #4_ Sander van Schijndel (Investor)"). The X-Decks concept is targeted on outcompeting the slow reaction time in balancing demand and supply (Dijkstra, 2017) of current parking projects with a temporary solution that shall lower vacancy risks and give a high financial security in this market segment newly accessed by RHDHV. Traditionally, the competencies of RHDHV lay in the field of engineering consultancy. With the X-Decks project, RHDHV wants to challenge itself by taking over the role of a developer and innovating a parking building over its whole lifecycle in a technical, managerial and financial way.
The principal idea is visualized in Figure 3. The site, structure and services to build, operate and maintain the parking space shall be leased from the companies that are involved. Furthermore, the stakeholders of the X-Decks project shall get the possibility to turn their commitment to the X-Decks project into shares. By providing land, building material or services, these shares give them direct participation in the future revenues of the parking space. Also, shares shall strengthen the long-term commitment of the involved parties by increasing their interest to provide long lasting and reusable products, since they would take over liabilities for the maintenance of their products (Netherlands, 2015; Tissink, 2017).

Circularity and transparency
These are the two key concepts of the X-Decks project. First, the use of a modular, reusable construction system and possibly bio-based materials to maximize the residual and salvage value while minimizing waste. Moreover, transportation and disassembly costs shall be minimized by a fast and adaptable assembly system. A first parking structure with these principles is already in operation in Purmerend (Park4All, 2018).
Second, transparency towards stakeholders of the X-Decks project during the whole building cycle is one key component to compete with traditional business models in the parking industry. Like described in the problem statement, the building industry is characterized by the creation of organizational silos. This shall be challenged by turning the information and business flows of the X-Decks project into the opposite of a 'black box' for the involved stakeholders. This thesis research will join this process to provide new approaches to the traditional hierarchy, common in the building industry.

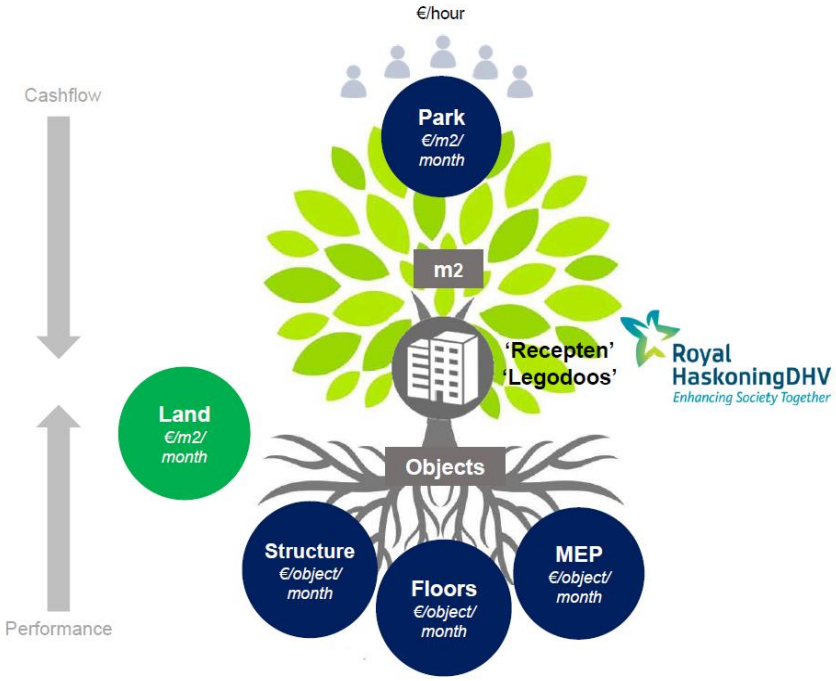


Figure 3. Optimization of technical value (RHDHV, 2017)

X-Decks: an incubator

Parking is intended as a starting use case that can be expanded in its functionally based on the same construction principles in the future. Residential and commercial functions are imaginable, which can be seen as the next step when the parking use case proofs itself to be successful. The less complex parking typology shall serve as an incubator for further and more complex functions.

Services beyond parking

The X-Decks buildings shall not stay isolated by themselves but interact with customer-oriented platforms like ParkBee, Parkmobile, TomTom, Google Maps, etc. through a Programming Interface (API) e.g. with the occupancy level. This shall strengthen the Business to Costumer relation. Also, the usage of parked electrical cars as a decentralized energy hub is a possible feature for the future.

From Park4All to X-Decks

The predecessor, Park4All, of the X-Decks project was successfully established mainly by its innovative, modular construction principles (Park4All, 2018). The Park4All project provides a modular construction system for temporary parking solutions. Design and construction knowledge from RHDHV are combined with a light weight, easy to disassemble floor panelling from an external manufacturer, lightning from Philips, steel from Brink Staalbouw and a contractor responsible for the erection and storage of materials. Park4All is an independent company which serves the clients' needs to have one partner to initiate a building. The consortium works in the background.

The stakeholders involved in the Park4All project are organized in a classical, hierarchical way. Figure 4 visualizes a classical, hierarchical organigram, that shall be representative for many parking and building projects. It visualizes what is described in the 'problem statement'; organizational silos are created through a black-box mentality of the upper stakeholders in the hierarchy. Especially the developer and contractor are interested to keep their business and information enclosed to pressure the sub-contractors and manufactures beneath themselves. This is founded on the lowest price tendering principle: the lower the developer or contractor tender the services needed, the higher the

profit margin. Since the Park4All project is a running business model it shall not be challenged, but a new supply chain shall be established for the X-Decks project.

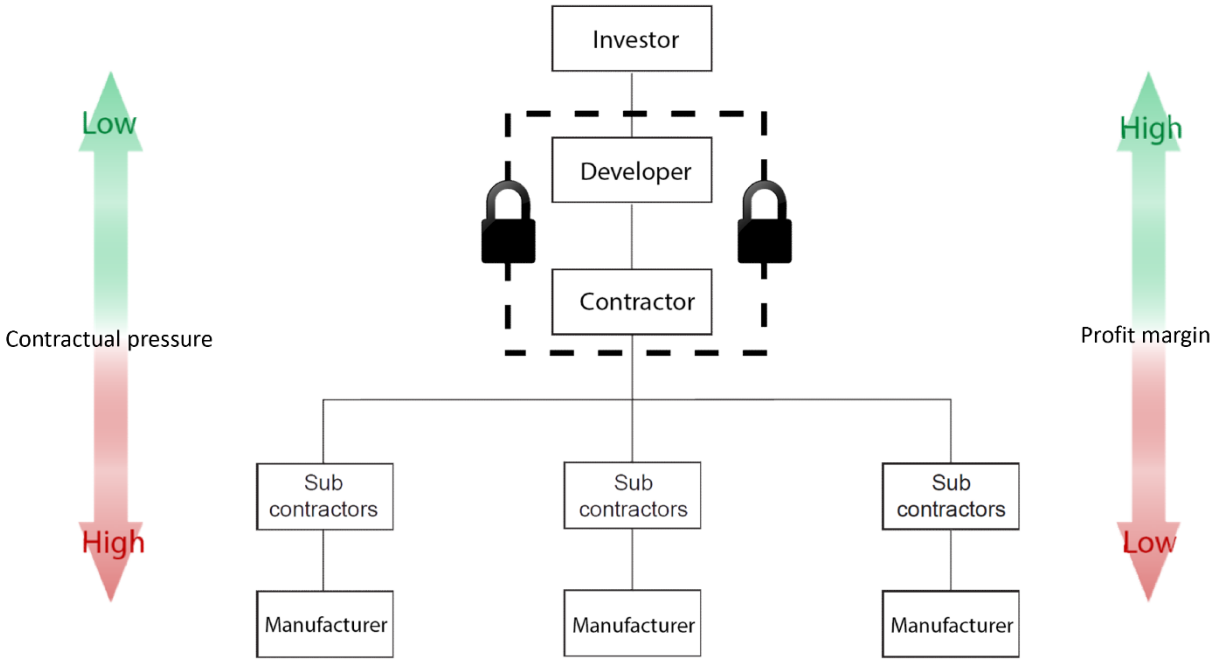


Figure 4. Organigram of a predecessor of the X-Decks project. (own illustration)

RHDHV has a broad network in the building industry to find the right parties to initiate and change these processes. Public parties are rather observers when it comes to new technologies and small companies usually do not have the capacity and network. Investors, developers and contractors are profiting from the current system. So, Royal Haskoning is in the right position to push this new business approach.

Access new business segments

The aim of RHDHV is to get a grip on services that they do not provide yet. Considering the PDCA circle (Figure 5), RHDHV is currently mainly active in the "Plan" section. "Do" and "Check" is mainly in the hands of contractors and these usually do not have access to the operational costs. "Act" is controlled by operators and asset managers. Closing the gaps of information loss between the steps is here one of the main goals from the side of RHDHV. A better grip on the whole information loop can lead to better predictions and scenarios over the lifecycle of a building. It can further help to standardize and digitalize the processes of the X-Decks projects and extend the services of RHDHV over the whole lifecycle of the building.

Figure 5. PDCA Circle (Roser, 2016)

Further information about the X-Decks can be found in "Appendix 1 – Further X-Decks details".

Literature review

The following literature review gives an in-depth introduction to blockchain technology and associated development in the field. Towards its end, the first sub-question is answered: *What is blockchain and how can it facilitate decentralised utilities?*
Also, Key Performance Indicators (KPI's) are derived for the X-Decks project and the second sub-question will be answered: *What are the key features of the blockchain technology in application to the X-Decks case?*

Introduction

The rampant growth of cryptocurrencies and blockchain technology causes a lot of excitement for individuals as well as for the business environment (coin.dance, 2018; Friedlmaier et al., 2016; Rückeshäuser, Brenig, & Müller, 2017). Optimists forecast a fundamental, global change in the way payments, economics and politics are made. Pessimists point out a rising bubble that will lead to a spectacular collapse (Arvind Narayanan, 2016).

This thesis research shall help to take a look behind short-sighted media reports and support an audience rooted in the building sector that is curious about blockchain technology. Blockchain technology is still in its infancy although it is nearly ten years old (Nakamoto, 2008). This literature review shall further help to contribute to the limited body of knowledge of blockchain technology and possible applications in the building sector while helping an audience that is not native to computer science, to form a critical view towards one of the most promising technologies that is in development at the moment and to find out what it takes to become an early adaptor in this field.

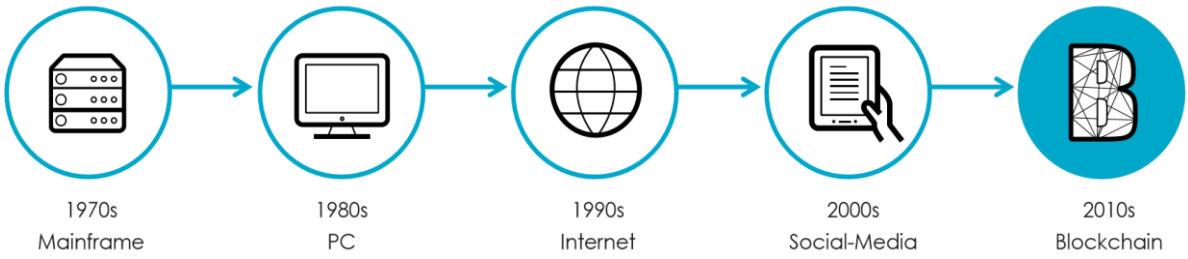


Figure 6 Internet of value (Evry, 2016)

Figure 6 gives a short overview on how the usage of computers has changed over time. Mainframes are for large companies what the PC is for individuals, with the difference that mainframes are more powerful for processing large amounts of data (Gupta, 2017). The introduction of the Internet made knowledge available for free, worldwide. Wikipedia, a decentralized, worldwide network of authors, replaced the Encyclopedia Britannica, which was printed for 242 years until 2010. With the Internet of shopping and the following social media platforms, the internet got commercialized and privacy is a rising issue. Now, with blockchain technology, there is an upcoming opportunity to add a new layer of value to our networks, where assets can be traded between two parties without the need for middlemen. It can be seen as the first native digital medium for value, just as the internet was "the first native digital medium for information" (Vavilov, 2016). The consequences and impact are still to be discovered.

What is a blockchain?
Blockchain is a data structure with an automated way to enforce trust among participants. Consensus algorithms ensure that all participants agree on the data stored within the blockchain.

It can be illustrated as a sequence of virtual blocks. This sequence is a continuously growing list of data that is protected by encryption. Each block consists of three parts: transaction data, a hash string or hash pointer that is linked to the previous block and a timestamp. A blockchain acts as "an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way "(Iansiti Marco, 2017). A distributed ledger is managed through a peer-to-peer network that runs a common protocol, known by all nodes, to validate the blocks. The blockchain protocol is secure by design; to exploit vulnerabilities in the data history, previous blocks need to be manipulated. This is not possible as long as a majority of the nodes are not having malicious intensions.

What is blockchain technology used for?
In first instance, to secure data and record transactions. Each block on a blockchain has a limited amount of data and transactions capacity. When the data or transactions are validated, a block is added permanently to the blockchain, secured by cryptography and a timestamp. To add new data, a new block has to be created and validated. In this way, no identical data can be added twice. This procedure is executed automatically which saves the necessity for intermediates to double check the data, like banks in the case of Bitcoin.
Beyond cryptocurrencies blockchain technology can be potentially used for medical records (Ahram, Sargolzaei, Sargolzaei, Daniels, & Amaba, 2017; Marshall, 2017), electronical voting (ENISA, 2017), recording of notarial and legal work like patent rights, contracts, insurances, policies and claims (Arvind Narayanan, 2016; Firica, 2017; Püttgen & Kaulartz, 2017), replacement of central clearing houses like Visa and Mastercard (Brennan, 2016; EBA, 2016) and more (Hyperledgerwiki, 2018).

Who invented the blockchain as it is used today?
A so-called person or group named 'Satoshi Nakamoto' (Nakamoto, 2008) released 'Bitcoin: A Peer-to-Peer Electronic Cash System' that conceptualized a distributed blockchain in 2008. In 2009, it was implemented as the underlying infrastructure of Bitcoin. There, it is used as a public ledger for all transactions.

What is so innovative about Blockchain?
Blockchain combines peer-to-peer networks with public-key cryptography, timestamping of transactions and distributed consensus that was not done in this way before (Nakamoto, 2008). Bitcoin is hereby the first digital currency that solved the double spending problem without involving intermediates, through blockchain technology. Double spending means in this context spending a certain amount of digital money simultaneously twice (see Chapter 'Consensus').
The disruptive potential of Blockchain technology is rooted in turning the flow of information and transaction data inside out; the control over transactions is shared with all users of a network. This ledger is decentralized and is not owned by one central party but belongs to all members of the blockchain network. Beyond that, a replication of the network is available for each node for download, which makes the system more transparent and secure than centralized systems. Blockchain opens the door to disrupt any industry that relies on a central authority to confirm authenticity (Friedlmaier et al., 2016). It also allows independent, and even competing organizations, to share information and gain efficiencies on an inter-industry level.

Why do we need blockchain technology (in a broader context)?
The internet as we know and use it today, is mainly run on the servers of centralized companies like Amazon, Google, Facebook that supervise content and collect information, which comes along with high threats for the privacy of its users. The users have little power to influence the collection of their data, which is usually sold for marketing purposes. Furthermore, the market leader in their segments, like Uber or Airbnb participate financially in the users' activities. Blockchain technology will open up the possibility to run a software like Uber or Airbnb based only on the computational

resources of its users. Similar to Bitorrent, once the software is mature the users can run their network without middlemen (BimWorld, 2017). Furthermore, a decentralization comes along with a higher reliance, which lower the chances of downtime through attacks or system failures. Spectacular data breaches (Hackett, 2016; McGoogan, 2017) might become a problem of the past. The current discussion about the abolishment of net neutrality might set these possibilities at risk

Key concepts

To summarize the findings from the questions answered above the following key concepts are important to understand:

Centralized, Decentralized, distributed
Figure 7 visualizes the concepts of centralized, decentralized and distributed networks. As mentioned above, most of today's digital infrastructure is centralized. With cloud computing we are moving towards the second step of decentralization, where central nodes still coordinate the others. With blockchain technology, there is a chance to create networks with equally positioned nodes.

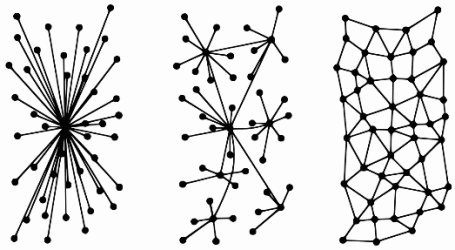


Figure 7. Centralized, decentralized and distributed networks (digitech, 2017)

Transactions are the centre of focus of every blockchain. The main reason why blockchain technology was invented was to replace conventional trusted third-party relations with a two-party relational system. Every transaction requires a sender "Alice", a transaction message "m" and a receiver "Bob". When a valid transaction takes place, the receiver has control over the message or asset. The asset can again be spent with the use of the hash-value as an input.

Digital signatures link the blocks of a blockchain together. Digital signatures verify the integrity of transaction messages and authenticate the transaction sender. One way to use digital signatures is RSA, a public-key cryptosystem. RSA uses an asymmetric (public key) cipher system, which means that messages are encrypted and decrypted by different keys. On the opposite, symmetric cipher systems use the same key for encryption and decryption. RSA is rooted in the difficulty of factorising large integers.

Hash functions help to save time when signing a transaction. Hash functions take an input string of any length and turn it into a new string with pre-designated length. It is important to use a collision resistant hash function (Arvind Narayanan, 2016) so that it is easy to compute a hash from a given string but that is computationally unfeasible to draw retroactive conclusions from the hash back to the string. Therefore, good hash function does not show any connections between input and output, what means that if just one letter of the input is changed the hash has to be completely different. While a hash function can guarantee the authenticity and integrity of a transaction message, it cannot verify ownership, because a message can be distributed innumerable times, the so called 'double spending problem'. Timestamps and blocks help here further.

Timestamping creates a unique identity of every block and links it to the previous block. In combination with cryptographic hashes, timestamps link the blocks together and create a resilient record of every transaction on a blockchain network.

Blocks are a chronological collection of transactions. Hash strings of the respective previous block are used to link the blockchain together. Changing the content of one block would mean to change all subsequent blocks too, because the hash string of all the subsequent blocks would change, which makes it suspicious to the network. It can be said, that the more consecutive blocks are added, the more immutable is the data. Furthermore, blocks and the included transactions are unique through their timestamps.
A block includes usually four types of data (Figure 8):

- A hash as a link to the previous block
- A timestamp
- A Merkle tree root to organize transaction data efficiently
- A nonce as a proof of work (not necessary for private blockchains)

Merkle trees
It is a way to organize transaction data efficiently with little disk space. In order to verify a transaction simply, the root hash (Tx0-3 in Figure 8) and the transaction hash are necessary. A transaction is verified with chaining the hashes up to the top of the Merkle tree. The "roots" can be tested for validation with the root hash.

Consensus
Every blockchain network includes a consensus algorithm. It serves as a decision process to create one single truth on a decentralized network. Further elaboration is provided in the chapter "Consensus".

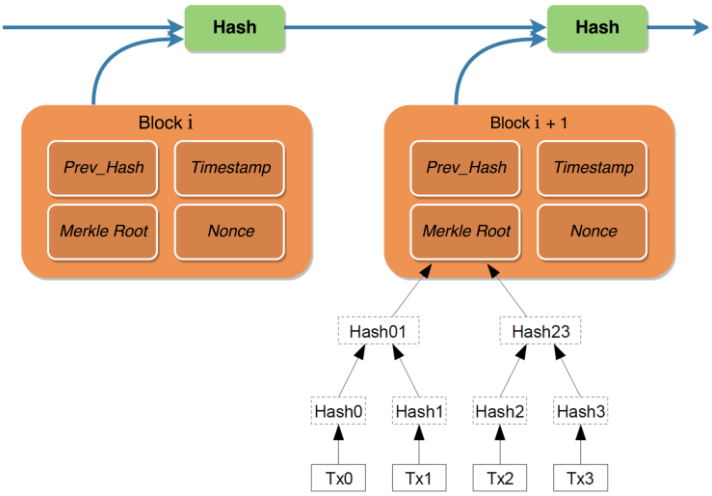


Figure 8. Data in a block with Merkle root

Defining blockchain

There is no consensus on the term 'blockchain'. The main functionality is decentralisation, but also companies have different interests and different points of view about it, and set their focus on other attributes like transparency, efficiency, security, etc.
In principle, in a trusted and private environment, blockchain has no benefit over a distributed database. However, it could still benefit from transparency, efficiency, security and it will be a good backbone to be further extended to a real blockchain system with untrusted parties.

To define blockchain it is important to understand the concept of distributed databases and distributed ledgers (see next chapter 'Related technologies'). These terms are indeed rather difficult to distinguish and are abused a lot. The key point is; terms have a **literal meaning**, but their **real (actual) meaning** might change over time. For example, internet does not mean the same thing as 30

years ago (an interconnected computer network). But now, internet means the Internet which most computers are connected to.

Below, the literal meanings and the meanings that people are using for blockchain technology, distributed databases and distributed ledgers.

Distributed database:

- (Literal) distributed database (see: p.22), so blockchain falls partially into this category.
- (Actual) distributed databases are a very classical topic. So traditionally, Byzantine Fault Tolerance (BFT) is not considered but just normal fail tolerance. Hence, blockchain is NOT a distributed database, since all classical distributed database systems CANNOT work in an untrusted environment which blockchain is mainly designed for.

Blockchain:

- (Literal) data in a form of chained blocks, like Bitcoin.
- (Actual) it also means blockchain technology, which is basically everything inspired by Bitcoin. This part is really confusing because it includes too many things. There is no clear definition of what blockchain actually is.

Distributed ledgers:

- (Literal) similar to distributed database, it means any ledger in a distributed form. Then, it is a subset of distributed database.
- (Actual) unlike distributed database which is a well-defined classical topic, distributed ledger is also an old topic, but basically reinvented after Bitcoin, so in principle Bitcoin is a distributed ledger. A distributed ledger is not a classical distributed database. Distributed ledgers and Distributed Ledger Technology (DLT) are becoming mainstream for two reasons: first, some companies like R3 try to claim that they are more advanced than blockchain, since it is not in a "blockchain" structure. Second, some people from academia, especially distributed databases researchers try to take credits from the hype of blockchain, so they want to define blockchain as distributed ledger technologies and claim it is part of distributed database research.

In this research, blockchain technology and distributed ledgers are considered as the same. At least, while being used, they actually mean the same. For example, although R3 claims that they are not using blockchain, it can still be closely compared to blockchain and both are essentially the same except that there is no "blockchain" structure. It seems that blockchain is a subset of Distributed Ledger Technologies, that is also why many people claim it as a DLT (Meunier, 2016). However, blockchain also includes something which is not a ledger, e.g., Ethereum (see chapter 'Blockchain providers'). Hence, since neither of these two terms literally includes the whole field, in this research the term blockchain technology will be used, since this term is already highly abused, and many people have an idea of what it is. Distributed ledger technologies are even more irritating and do not capture the whole scene, so there is no point in introducing this term instead of blockchain technology.

Related technologies

To further understand the 'Defining blockchain' chapter, Distributed databases and Distributed Ledger Technologies (DLT) are discussed here in further detail.

In the 1980s, the traditional and currently most common form of databases**, centralized relational databases,** became standard. These are used to organize data in tables commanded by the SQL language. There were further developments in its architecture (distributed processing, n-tier) but relational database management systems (RDBMS) remained centrally stored and maintained. More than 90% of databases are organized in this way with established providers like Microsoft SQL Server, MySQL, IBM DB2, Oracle, SAP, etc.(Meunier, 2016)

Distributed databases
Distributed databases are used when data is stored across a network with no central processor. Through rising popularity of the internet, businesses where looking for possibilities to process structured as well as unstructured data on scalable networks. Distributed databases can have an implemented consensus and timestamping mechanism to establish concurrent control and a fault-tolerance communication. The following services exist:

Peer network node data stores help users to exchange data on a peer to peer (P2P) network with protocols like BitTorrent, Freenet, NNTP, etc.

Distributed SQL data warehouses are created to process high volume data analytics provided by major players like (Microsoft, Oracle, SAP, IBM).

Hadoop helps to store massive amounts of data and process concurrent tasks. The software is open-sourced.

NoSQL stands for non-relational distributed databases that are conceptualized for real-time web applications and horizontally scalable. The main providers are: MongoDB, Apache Cassandra, Google BigTable and CouchDB.

NewSQL databases are relational databases that merge the functionalities of DDBMS and NoSQL. This means that horizontal scalability and distributed processing are in cooperated. Providers are: Trafodion, MemSQL, Google Spanner.

Distributed Ledgers (DL)
Distributed ledgers are at the heart of blockchain technology. Cryptography and consensus mechanisms ensure that coherent data is added among untrusted nodes. Consensus and immutability are also part of distributed databases but the difference of distributed ledgers is; **the permission to read and write is truly decentralized and transactions are securely processed without any intermediates.**

Currently the most popular Distributed Ledger application is Bitcoin. It is censorship resistant and unites the following features; accountability (time-stamping), pseudo-anonymity, auditability (public), byzantine-fault tolerant, immutability and non-repudiation (signature) at transaction level.

At the moment, the most popular cryptocurrencies are inspired by the Bitcoin architecture with some modifications like:

- An improved privacy, anonymity mechanism (Zcash, Monero) and different consensus protocols like Proof of Stake, Proof of Elapsed time, Proof of Burn, Proof of Capacity (Castor, 2017) and many others (explained in Chapter 'Consensus').
- The Ethereum network extends the functionality of currency-focused applications and offers a programmable transaction environment for smart contracts.

Systems that are also based on distributed ledgers but distinguish themselves more fundamentally from cryptocurrency based systems are:

- The R3 Corda project and the similar DisLedger project, aim to improve transaction processes for financial institutions. Information and transactions are exchanged in a permissioned environment where every node is known. Information within this permissioned environment can be confidentially handled and exchanged only between two parties.
- HashGraph uses the so called 'gossip protocol'. Consensus is reached through a virus like spreading of information from one member to another. Therefore, the nodes collect information they do not have yet and data can be verified when most of the nodes 'have heard about it' and the information does not conflict with any existing one.
- Tangle IOTA and further examples are explained in 'Blockchain providers'

BigChainDB is conceptualized to store data in a scalable and distributed way. It offers the features of a blockchain; resilient, decentralized and recording transactions while merging it with a distributed database. It can be linearly scaled and operated with NoSQL. Furthermore, information can be filtered through permissions.

Summary

The development from centralized relational databases to distributed databases and further to distributed ledgers added incrementally a higher level of decentralization to the system. While centralized relational databases and distributed databases are technically mature, this is not the case for distributed ledgers yet. Nearly every week a new, 'revolutionary' idea is coming up in the field of distributed ledgers. This makes it quite hard to get grasp of a clear overview in this field. The most important concepts are outlined in the chapter 'Blockchain providers'.
Applying this knowledge to the building industry and to the X-Decks project, it can be said that in a trusted and private environment (e.g. B2B), blockchain has no benefit over a distributed database when it is just operated with a couple of nodes. However, it could still benefit in transparency, efficiency, security and it will be a good backbone to be further scaled up to a real blockchain system with untrusted parties. Providing untrusted parties with full admission rights to a centralized relational database or distributed databases is a major threat and under no circumstances advisable.

Considering the 'latent value of a technology until it is commercialized' mentioned under 'Research methods' (Chesbrough & Rosenbloom, 2002), blockchain technology has this latent value right now. Since Bitcoin is the only mainstream application by now, the potential for the business environment and especially for the built environment is hardly touched. When first applications beyond Bitcoin will proof themselves successful, it "can be viewed as a change in the business environment that requires companies to adapt their business models" (Haaker et al., 2017).

Public and private blockchains

Now that the rough principles of blockchain technology are defined and a grasp of related technologies was given, let's dive deeper into blockchain technology to see what kinds of blockchains there are.

In principle, there are two different kinds of blockchains; private and public ones. In **private (permissioned) blockchains**, a consortium is responsible for authenticating and controlling the participants on a blockchain network. In **public (unpermissioned) blockchains**, no central authority or administration is required to exchange data (Zheng, Xie, Dai, Chen, & Wang, 2017).

On the Bitcoin network, for example, every node can review transaction records, and participate in the verification process. Bitcoin is operated on an unpermissioned public ledger. But, there are also other categories of ledger that organize the 'levels' of read and write permissions in a different way.

Traditional ledger: it is centralized and solely the ledger's owner that has read/write permissions. It is mutable and needs to be aligned with other ledgers to clear transactions.

Permissioned Private Ledger: solely permissioned nodes have access and read/write permissions. In contrast with the traditional ledger, there are multiple parties with equal rights involved, consequently, the ledger is decentralized.

Permissioned Public Ledger: everybody can read content of the ledger, but only permissioned parties have read and write permissions.

Unpermissioned Public Ledger: it is a fully distributed system that allows read and write permissions for every member, as long as they follow the logic of the network.

Furthermore there are also hybrids of the different ledger categories possible, the so called "multichannel blockchains" (Binh Nguyen, 2017). These can combine, for example, a permissioned private with a permissioned public ledger. The ledgers are maintained separated but data can be exchanged between them.

The selection among unpermissioned and permissioned blockchains is dependent on the specific case. Private, or **permissioned, blockchains are suitable for businesses that want to cooperate with trusted parties**. To even emphasise it; they need to trust each other, otherwise the cooperation would just open doors for fraud. In this sense, a private blockchain is not using the full potential of blockchain technology but rather stays more centralized for the sake of confidentiality.
Most companies have a connection with potential stakeholders or have heard about their reputation before they do business with each other. A supply chain is a good example where information and assets are exchanged between companies and can be used to demonstrate a permissioned ledger application. Non-vetted companies should not be participating on the network. Every company that shall be part of the supply chain needs an authorisation to access and participate on the network. Important to consider is "garbage in, garbage out": so, the "level of truth" is determined by the logic of the system. If data is not building upon each other and nodes can hinder the system performance by adding unnecessary or even manipulative data, a blockchain network does not bring advantages to other systems. Therefore, permission of nodes and data to a permissioned network has to be kept high.
Furthermore, it is important to keep in mind that the smaller (private) the blockchain network, the more it resembles classical, centralized structures. Consequently, it is less secure and more vulnerable to fraud.

On an unpermissioned ledger, trust gets “commoditized”. Everybody can join the network, and trust is really distributed among nodes that do not know and trust each other, like in the case of Bitcoin. Since such networks can reasonably expect all kind of participants - including malicious actors - the key lies in incentivizing good behaviour in a critical majority of the network, such that:

- The malicious actors cannot take over the network through an escalated attack.
- The malicious actors cannot collude to undertake an organized majority attack on the network.
- The payoffs of securing the network are consistently higher than the cost of attacking the network.
- The cost of attacking the network is prohibitively high.

Furthermore, it needs to be considered that unpermissioned blockchains stimulate the innovation potential of an open source community and offer easier inter-operability.
Many operators of unpermissioned blockchains offer public token sales. Initial Coin Offerings (ICO), are usually run on a unpermissioned blockchain.

Figure 9 summarizes the advantages and trade-offs between permissioned and unpermissioned blockchaina. Generally it can be said that permissioned blockchains can be run more cost efficiently, but as trust is increased in permissioned authors, distribution is declining what guarantees ledger integrity.

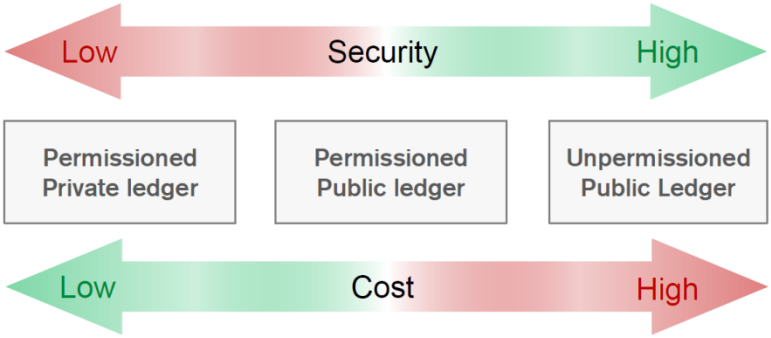


Figure 9. Cost vs Security tradeoff of blockchain types (Brennan, 2016)

The right blockchain type for the X-Decks case
As mentioned above, permissioned blockchains are suitable for businesses that want to cooperate with trusted parties, which is the case for the X-Decks project. Since the potential external stakeholders will go through an extensive vetting process, they can be considered as trusted. Even if a party wants to deceive the system, the data will be visible for every other party and suspicion will arise. Beyond choosing a permissioned blockchain, there are possibilities to link an unpermissioned blockchain as one node in the system to a permissioned blockchain. This might be of advantage when, on a long-term perspective, it shall become possible to involve the public, when paying parking fees on a blockchain system.
A public link does not directly suggest that it is a public chain. It means that the public is involved in maintaining the ledger (database), what suggests that the unpermissioned chain is not only user, but also the owner and controller of the blockchain, and they need to get paid for providing their computer power to maintain the system, e.g. by tokens or a cryptocurrency.

A possibility is to have a blockchain consortium for business entities, and a public blockchain for parking fees, either a new one with its own token or an existing public blockchain like Ethereum. The public blockchain can be seen as one entity in the consortium blockchain. Technically, this is the same as in the ecosystem of Bitcoin and Ethereum, where side-chain or off-chain techniques are used like RSK and Polkadots. However, it differs in business logic. In the ecosystem of a public blockchain, all data on the side-chains are closely related to the public blockchain, like in Ethereum. On a permissioned B2B blockchain with a public link, the blockchain does not belong to the ecosystem of the public chain, it only sees the public chain as one party in the consortium.

Concluding, it can be said that a permissioned blockchain is more suitable for the X-Decks case in the starting phase. Since the 'Focus Group' of external stakeholders (Chapter 'Dissemination and audiences') will act in a B2B environment, there is no gain in the starting phase to make data publicly available. Just on a long-term perspective it might be desirable to include the public on the blockchain to make possible the direct distribution of payments of the parking fees via a blockchain system.

Further key concepts for blockchain technology

In this chapter, further key concepts about blockchain technology are explained that go beyond the introductory description. "Appendix 2 – Further blockchain concepts" is a continuation of this chapter.

Consensus

Consensus is a system to secure that participants are in compliance with a certain status as the genuine status. For that purpose, transactions are distributed over the whole network, validated by the responsible nodes and updated to each node in the same order. This process is called consensus. It plays a crucial role on a blockchain network by filtering right from malicious data and creating trust between cooperating stakeholders (Hyperledger, 2017b; Vavilov, 2016).

A key issue that all consensus algorithms have to solve is the Byzantine Generals' Problem, also known as the 'double spending problem'. This means that under all circumstances, it has to be prevented that one asset on a blockchain can be spent twice, in the same moment of time. This is called Byzantine Fault Tolerant (BFT). In order to be Byzantine fault tolerant, "the number of nodes that must reach consensus is **2f+1** in a system containing **3f+1**, where **f** is the number of faults in the system" (Goodwin, 2017).

The following consensus algorithms are among the currently most used or promising ones (Zheng et al., 2017);

Proof of Stake (PoS) – participants on the blockchain are selected in a random order but the frequency of selection depends on the assets or stakes that one node holds on the network.

Proof of Work (PoW) – is native to Bitcoin and requests to find a random, computationally intense to proceed string (also called nonce) in order to create a new block.

Tangle - carries no economic incentive. Instead, it is designed in a way that requires all users to verify two transactions every time they wish to carry out one by themselves. The Tangle is related to the IOTA project.

Proof of Elapsed Time (PoET) - is introduced by Intel and provides a patented hardware-based lottery function to select nodes most efficiently to create the next block.

There are also other consensus algorithms like Proof of Burn, Proof of Ownership, Proof of Publication that do not contribute further to the X-Decks case but might be helpful for other use cases.

The PoW algorithm requires a high amount of energy to be expended, given the computationally heavy algorithm. In addition, PoW has a high latency of transaction validation, and the concentration of mining power is located in countries where electricity is cheap. In terms of network security, PoW is susceptible to the '51% attack'. This is a vulnerability that supposes that >50% of mining power is controlled by one party or group of miners. For the X-Decks case, PoW it is not suitable since a high amount of computer power is used to operate the blockchain in a untrusted environment, which is not necessary for the X-Decks project.

PoET and Tangle are strongly linked to its inventors, Intel and IOTA, respectively. Since both consensus algorithms are not open sourced (yet), it cannot be estimated, if they will proof themselves in the future. Both are very promising, especially when it comes to the amount of transactions per second that can be processed. But, in the case of X-Decks, this is negligible since the 'Focus Group' will have a manageable amount of members and transactions. Just to give a feeling, PoET is advertised with processing 1600+ transactions per second while BFT typically delivers 100s of transactions per second (Echevarria, 2017; Goodwin, 2017). PoET and Tangle are particularly interesting when it comes to inter-operability with Internet of Things devices. When many devices are obliged to communicate in a high frequency with each other.

The PoS consensus algorithm distributes voting rights according to the assets hold on the blockchain, e.g. if one party holds 30% of assets it is chosen to commit 30% of the blocks. This is not a computationally intensive task like in PoW, but it might lead to monopolistic decisions and underrepresented parties on the blockchain when a stakeholder holds more than 50% of stake and wants to act maliciously. But, this malicious behaviour is rather trivial on a permissioned blockchain since all stakeholders are vetted. Further, if somebody wants to commit false data, it is still visible for all other stakeholders on the blockchain who committed the data and they would lose trust in this node.

A last option that is not mentioned above is to vote manually, so that every party has equal voting rights, or like in PoS, voting rights according to the assets held. To add a block a summed-up agreement rate of e.g. >50% has to be reached between the parties. This barrier can also be set higher, in case too tight decisions shall not be accepted. The downside is that the parties need to agree manually. This might work well in a small 'Focus Group' but gets inefficient when the blockchain network is scaled up and shall work more automated.

Summarizing thoughts

Consensus algorithms are mechanisms where "all users within a distributed ledger agree on the validity of the underlying data" (ENISA, 2017). It is crucial to consider the consensus algorithm from different perspectives. In first instance, it shall be a barrier to manipulate and add random data to a blockchain. Second, it shall create trust between the nodes, to operate on a transparent and reliable system. Actual validation of data depends always on a majority of the network being trustable within

every consensus algorithm. Therefore, the consensus is just a system to support good behaviour, the outcomes are determined and evaluated by its users.
Consensus can be reached through setting a computationally intense task like in PoW, a hardware-based solution like in PoET or through voting like in PoS and Tangle. In a first pilot with a limited number of stakeholders, manual voting might be advisable but on a later stage when automated transactions shall be implemented and the blockchain shall unfold its full potential, PoS is the better choice.

Side remark about trust:
Trust in the system does not actually mean trust in the case of blockchain technology, but control. Figure 10 shows that reliance splits into two directions. Blockchain technology is working with "incentive control" and "opportunity control". The result of these control techniques can eventually create "trust in the system".

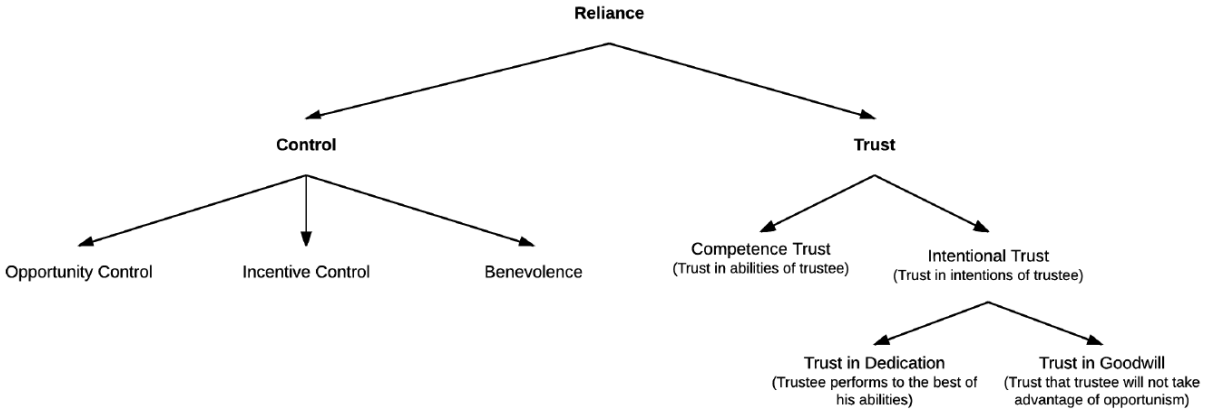


Figure 10. Conceptualization of trust (Nooteboom, 2003)

Smart contracts

A smart contract can be seen in direct connection with consensus algorithms because it automates the execution of predefined conditions. These predefined conditions are basically a consensus on a certain condition, like in a classical contract, and the smart contract is executed automatically when this condition is met.
Regarding this process during the creation of a block, the conditions for the execution of a transaction takes place before a transaction is sealed to a block (Figure 11).

"Smart contracts" originate from Nick Szabo, far away from the first blockchains, in 1994. He describes already the intention to replace intermediates by automatization and lowering transaction costs.
Smart contract technology is still in an embryonic stage. While blockchain is slowly stepping from an experimental phase towards first use cases, smart contracts are still in an experimental stage. This is due to the legal complexity of automated contracts that is neither solved in a business environment nor through a public institution (Greenspan, 2016). Furthermore, smart contracts are dependent on a resilient data system like blockchain.

Nevertheless, the “possibility to embed funds within a Smart Contract, and the possibility to interlink different contracts in order to create a chain of events, such as payments”, might be a key to increase efficiency in the building industry (Cardeira, 2016).

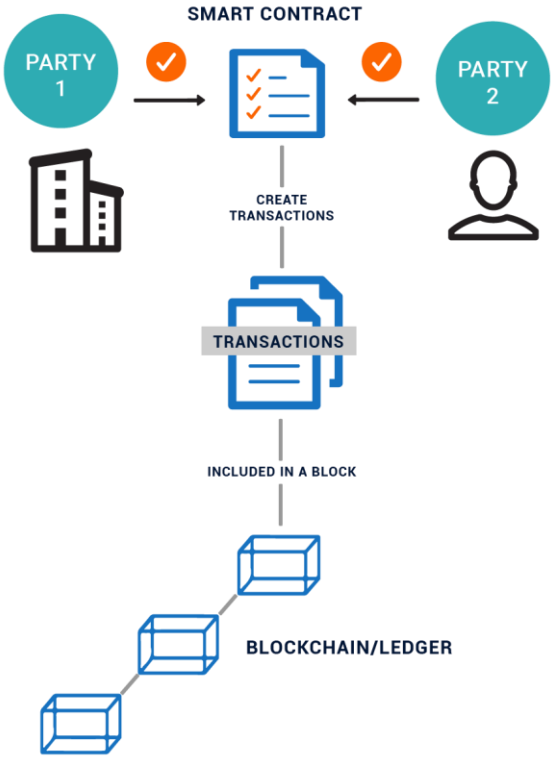


Figure 11. Blockchain and smart contract flow diagram (Linux, 2017)

The following Table 1 compares traditional contracts with smart contracts. The main difference is that traditional contracts have a bigger wiggle room than coded smart contracts. The processes of traditional contracts are deeply rooted in the routine of our society when compared to the rather disturbing automated process of smart contracts that offer little space for correction.

	Law	Software
Logic grounds	Subjective minds, analogy	Boolean logic
Security	Contempt, imprisonment	Replication and cryptography
Predictability	Flexible	Rigid
Maturity	Highly evolved and many cases	Embryonic and few experiences

Table 1. Wet vs dry code (Voshmgir, 2016)

It is still unclear whether courts will enforce blockchain contracts in the same way they enforce traditional written contracts, with inked paper signatures. Therefore, the current best practice is to record trades on blockchain, alongside traditional legal documentation. The operative clauses in the traditional written contract are converted into smart contract templates to be placed on the blockchain once a trade is confirmed. For example, a contract would be stored on a blockchain, and tied to the smart contract governing the underlying information processes. This leverages the predictable outcomes of a legal contract with the efficiencies that can be gained from a blockchain.

From paper based – to digital processes

Blockchain technology can also greatly improve reconciliation of corporates, both large and small. Today, reconciliation is a working intense process that involves manual matching of paper-based trades and payment documents. In addition to the increased chances of errors in processing, the process today is both time- and resource-intensive for both banks and corporates. Blockchain technology could radically simplify this process by enabling automated reconciliation and matching of trade and payment information, with full transparency of the entire end-to-end value chain available to all parties of the transaction. This allows all participants to have real-time visibility of completed and outstanding transactions without the use of multiple copies of paper instruments. The real-time visibility and ability of all participants to update the ledger in a transaction also creates a transparent playing field that does not exist today. Instead of relying on a centralized party to maintain a ledger and provide information to different stakeholders, blockchain technology enables multiple gateways to an indisputable ledger. This not only enables faster actions to be taken by different parties, it also boosts convenience for all participants by giving them real-time access to reliable information surrounding the entire processes.

Smart contracts in the case of X-Decks

During the interviews, it is crucial to study the business and information processes of the external stakeholders to identify possible paper-based processes that can be translated to digital smart contracts. Further, it will be important to investigate to which extent external stakeholders are interested in digitalizing their processes and how to distribute liabilities during this process. This is why it is advisable to start with minor processes on a blockchain/smart contract prototype that are allowed to fail or that are backed up with traditional contracts before the blockchain will be established as the only source of 'truth'. This way, big failures like the DAO hack (Giancaspro, 2017) can be avoided.

Summary

Smart contract is a technology in a very early stage that offers to automatically execute predefined conditions that are in accordance with the transaction data e.g. on a blockchain.
The potential for smart contracts in the case of X-Decks is especially high when it comes to replacing paper-based processes that appear in a highly standardized way and frequency. A special focus on these processes will be set in the interviews to study the business and information of RHDHV and its external stakeholders.

Challenges of adoption and deployment of blockchain technology

The following chapter shall serve as a summary of the challenges that arise from the information collected during the literature review. This summary focuses on the adaption and deployment challenges for businesses. At the end of the chapter the first sub-question will be answered.

The promise of blockchain technology is to simplify and automate key processes. Businesses recognize the potential efficiency gains by transitioning from closed and proprietary solutions to open-source capabilities, since common standards across industries will be a key component for a wide adaption of blockchain technology.

Common standards
A major difficulty for the adaption of new technologies is the transition process. While dealing with a lack of knowledge, regulatory discrepancies and a lack of standardization, a new technology cannot fulfil its whole potential.
Different approaches, frameworks and consortiums in the blockchain space make it difficult to agree on common standards. On a mid-term perspective interoperability will play a key role to prevent a fragmented ecosystems. " Standards are critical not just for blockchain technology itself, but also for supporting services, like identity, privacy, and data governance. Furthermore, the management of keys, as well as protocols and standards around key loss and theft, will be critical" (Deshpande, Stewart, Lepetit, & Gunashekar, 2017(Zheng et al., 2017)).

An initiative that tries to give shape to the standardization process is the International Organization for Standardization for Blockchain and Distributed Ledger Technologies (Clare Naden, 2017). The according standard is ISO/TC 307 (ISO, 2018).

The missing standardization processes of blockchain transactions results in an environment of uncertainty. The same applies for smart contracts; programmers, businesses, institutions and lawyers progress here just in small steps.

Misconceptions and lack of knowledge
Experts in the blockchain space are scarce. Whereas interest in blockchain is increasing exponentially, it has not been converted into an according work force. In fact, the origin of this course stems from the need to address this gap in know-how, both for the business and technical audiences (coin.dance, 2018).

Confidentiality vs transparency
In a business environment, there is a high necessity to provide confidential channels where transactions can be closed e.g. just between two parties. Further, these confidential transactions need to be committed to the blockchain of all other member as a 'filtered' version and still have to ensure that this filtered version is trusted by all other nodes. Basically, information- that is not fully visible has to be trusted by all members relying on the system. This is a mostly a technical problem but can delicately damage the participants trust on a blockchain network.

Finding and replacing paper-based processes
Finding paper based-processes that can be replaced and automated on a blockchain is a main challenge for businesses. The rules of transactions in blockchain are often pre-set, and smart contracts do not change execution paths once they have been initiated. **Everything that takes place on a blockchain must be completely deterministic**. Additionally, blockchains are append-only databases. A relational database may be more suitable if there is a need to make many changes to your data as the rules of your transactions change.

Gap between digital twin and physical asset
This challenge is strongly connected with replacing paper based-processes. In first instance, it is more convenient to start replacing processes in which actual value can be digitally represented – like in the case of Bitcoin, all value is traded as a digital currency. Thinking about the building industry, where most of the value is represented in physical assets, there is a double effort necessary to manually maintain a digital twin. This double effort will remain until it is possible to observe and track physical assets automatically through sensors (IoT) and consequently be able to automatically maintain the

digital twin. As it is now, it is a burden to maintain a digital twin and the chance is high that deviation of data will occur.

Barriers from an organizational point of view:
Figure 12 gives an insight into potential barriers when introducing and implementing new technologies. The building industry is a rather late adopter of new technologies and the interviews will show if the barriers will be verified.

No.	Description of barrier	Source
1	A restrictive mindset	Sandberg and Aarikka-Stenroos (2014)
2	A lack of discovery competences	Sandberg and Aarikka-Stenroos (2014)
3	An unsupportive organizational structure	Sandberg and Aarikka-Stenroos (2014)
4	Financial barriers to innovation	Hölzl and Janger (2011))
5	Skill barriers to innovation	Hölzl and Janger (2011)
6	A lack of information on markets	Hölzl and Janger (2011)
7	A lack of information on technologies	Hölzl and Janger (2011)

Figure 12. Barriers of adopting new technologies (Patrick, Robert, Alexander, & Lodewijk, 2017)

Conclusions

In order to realize the full potential of a new technology, a lot of pieces need to come together. In the case of Blockchain, this means a critical mass is needed to reach systemic efficiencies. As an infrastructure technology, major players in the market need to establish common technological standards. This standardization process is the first challenge in the adaption process of blockchain technology. Especially when considering that many positions of middlemen are strongly connected to governmental institutions, which are acting rather reserved in the blockchain cosmos. In the private economy, the blockchain community is indeed witnessing unprecedented levels of industry collaboration between players which used to be competitors. At this point in time, an open source, collaborative approach is the most promising way forward.

Finally, blockchain cannot solve all the problems that are out there. It is crucial to focus on the key concept: decentralization and transactions. First, a proof of concept needs to be created. Then, first processes can be digitalized step-by-step on a blockchain network. When confidence in using a network rises, it can be scaled up. Within the methodical frame of this research thesis, the focus during the interviews is to identify paper-based processes between RHDHV and the external stakeholders for the X-Decks case.

Answering the first sub question

What is blockchain and how can it facilitate decentralised utilities?

A blockchain network is a distributed ledger that records all the transactions that take place on the network. The data structure of the blockchain network is distributed across multiple computer devices. Each network participant, can review all the transactions made on the network and even collaborate in its maintenance.

The immutability, coming through decentralization of the data on the blockchain is perhaps the most powerful and convincing reason to deploy blockchain-based solutions. Blockchain brings decentralization in first instance, thorugh that it creates higher transparency, security, efficiency or trust, which might be desirable in a business environment.
It also allows independent, and even competing organizations, to share information and gain efficiencies on an inter-industry level opening the doors to disrupt any industry that relies on a central authority to confirm authenticity (Friedlmaier et al., 2016).
Concluding, Blockchain technology facilitates decentralized utilities through peer-to-peer networks with public-key cryptography, timestamping of transactions along with a distributed consensus algorithm that was not done in this way before.

Key features for X-Decks

Distribution of liabilites

Looking back at the literature review, this chapter summarizes the most important lessons learned for the X-Decks project to answer the second sub question later in this chapter.
First, the aims for the X-Decks project are derived.

In first instance, decentralization is not a key feature for the X-Decks case but a necessity to create a **more transparent and efficient collaboration** for a temporary parking solution.
Strengthening collaboration and **trust between the stakeholders** in a new system is key to gain confidence and step together into the emerging blockchain cosmos. All participating stakeholders are requested to step outside their comfort zone to explore and implement new business concepts and free up unleashed potential that is currently wired in organizational silos.
Summarized in one sentence, it can be said that more **transparency in the X-Decks processes can enable a new business model**, increase efficiency, **distribute liabilities and facilitate trust**.

The following paragraph answers the second sub-question;

What are the key features of the blockchain technology in application to X-Decks?

Immutability
The “immutability of data on a blockchain network is perhaps the most powerful and convincing reason to deploy blockchain-based solutions” (Kiayias et al., 2016). This immutability makes blockchain useful to avoid constant checking, rechecking and updating of data in asset ownership, management and transfer. Furthermore, it is possible to qualify and quantify assets and investments. Furthermore, a **timestamp** can make the data even legally enforceable.
The mentality of not trusting each other is deeply embedded in the system because every single transaction is recorded and validated with previous ones, consequently there is no space for missing data. It follows the popular saying: trust is good, control is better.

Built-in-trust
Encryption is the basis of trust in a blockchain network. This allows members of a network to bridge middlemen, responsible for informational, physical and financial liabilities, common in supply chains.

Transparency
It can work against the creation of organizational silos. Information is shared between the members of a supply chain. Instant access to operational, financial and managerial data can help to eliminate current silos.

Traceability
On a blockchain network, multiple processes on a supply chain can be traced over the whole lifecycle of a building, service or product. This gives access to the origins of an asset but can be used at the same time to establish requirements for new assets. Moreover, preventive maintenance can be enhanced through the received data.

Permissioned blockchain
This is the right environment to start a pilot for the X-Decks project. A limited number of nodes like the 'Focus Group' (Chapter 'Dissemination and audience') would offer a trusted environment to experiment and automate first processes without being exposed to the public. When confidence in these processes rises, it is possible to scale up the network and even connect it to an unpermissioned blockchain, if desired.
Besides running a permissioned blockchain, it is important to incorporate a **stateful** blockchain that guarantees flexibility and easy programmability to adapt to changing processes.

Consensus
The right choice of a consensus algorithm and the right adjustment of voting rights within it play a crucial role to establish and maintain trust between the stakeholders on a blockchain. It is a combination of a technical and managerial challenge to design the right consensus for a specific business case.
In a first blockchain pilot of the X-Decks case, with a limited number of stakeholders, manual voting might be advisable but at a later stage when automated transactions and **smart contracts** shall be implemented and the blockchain shall unfold its full potential, PoS might be the better choice.

KPI's

The following chapter provides a collection of Key Performance Indicators that shall help to guide and evaluate the interviews and to later use the received information for the asset management framework. The KPIs are derived from knowledge gained during the literature review and from information about the case study of the X-Decks project.

In general, the KPIs are covering managerial, financial and operational information throughout every category. The same applies to the topics transparency and collaboration that run like a common thread through this thesis.

First, **Business and Information Flows** of the external stakeholders are studied. The corresponding questionnaire can be found in Appendix 3 - Interview Questions.
The first four KPIs evaluate mainly internal processes of the interviewees; how they perceive their role and which means they use to do so. Further, these KPIs shall help to analyse the current paper-based processes of the external stakeholders, to draw them up in the later process of this thesis research and to find out which processes could be efficiently digitalized on a blockchain.

- Role and responsibilities of stakeholder
- Business model
- Payment structures
- Information flows

The second KPI category is **Innovation and Frictions.** The interviewees are intended to reveal internal and external frictions and innovations. These are related to their own businesses, the built environment in general and the X-Decks case. The KPIs can be directly related to Figure 4 in the Chapter "X-Decks – Project Description". The stakeholders describe if they feel themselves represented in the organigram (Figure 4) and how they interact within the system.
Since circular processes and parking as a service play a key role in the concept of the X-Decks project it is important to find out if the external stakeholders carry out any circular processes already.
The conception of the external stakeholders to commit themselves to a temporary parking solution is important because this is a new business concept and it would require them to stand behind the project in a new role compared to their current business routines.

- Contractual procedures
- Parking as a service
- Circular processes
- Organizational silos
- Financing

The **blockchain**-related **KPIs** serve two proposes. On the one side, these shall reveal the current state of knowledge and interest on blockchain technology of the external stakeholders. On the other side, needs are projected to potential limitations and opportunities of blockchain technology in general and applied to X-Decks. Replacement of middlemen is here a sub-specification of opportunities through blockchain technology.

- Conceptions, expectations and misconceptions towards blockchain technology
- Needs
- Limitations and Opportunities (important: Degree of decentralisation/centralization, scalability)
- Replacement of middlemen

First steps toward organizational innovation

Figure 13 extends the previously introduced hierarchical organigram (Chapter 'X-Decks project description') with new cooperative proposals. Since the creation of materials or value takes place at the lower end of the organigram through the manufacturers and sub-contractors, the upper stakeholders are mainly working on coordinating and supervising the building process. Except for the investor who provides the financial means to the project. Considering that blockchain technology can enable a more transparent system through eqaully sharing data between all stakeholders, this would weaken the position of the developer and contractor whose business models rely on enclosure of information and working as middlemen between the parties above and below themselves.

The idea behind Figure 13 is to connect the manufacturers and sub-contractors directly with the investors and weakening or skipping the role of the developer and contractor. This can lead to an empowerment and a higher profit margin for the manufacturers and sub-contractors when they are willing to take over developers and contractors risks and responsibilities during the building process. For highly repetitive and predictable building typologies like a X-Decks parking garage, this is more likely than for other, more complex building types.

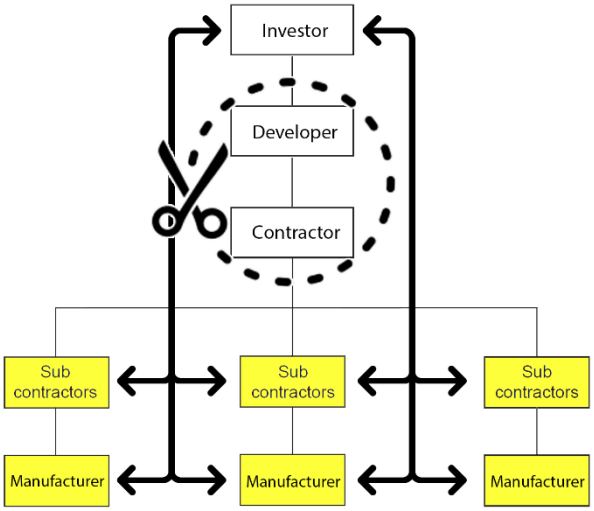


Figure 13. Challenging the current building process (own illustration)

Regarding the hierarchical organigram in Figure 13 and the linear diagram in Figure 14, it can be seen that every stakeholder is currently maintaining their own ledger. This leads to inefficiencies through manual updating, checking and rechecking. Especially when information with external stakeholders needs to be individually synchronized and different versions of the same document exist across different stakeholders. This can lead to delays or even wrong decisions based on outdated information.

Blockchain technology has the potential to change the linear and hierarchical building and management process (Figure 13 & Figure 14) to a decentralized and more transparent building process (Figure 15). Decentralized means here, in first instance, the way transaction data is processed and contracts are made. In the middle of Figure 15, a 'Shared Ledger' and 'Smart contracts' are placed. The shared ledger ensures that all the transactions of assets that are traded on the blockchain are in accordance with previous transactions on the blockchain and that all stakeholders agree on the validity of new transactions before those are added. With smart contracts the condition of agreement to execute a transaction can automatically be set.

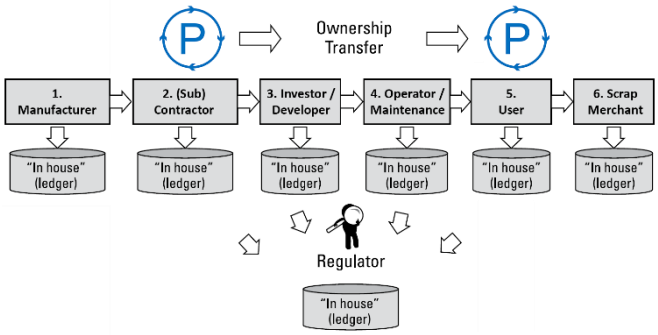


Figure 14. Linear ownership transfer (own illustration)

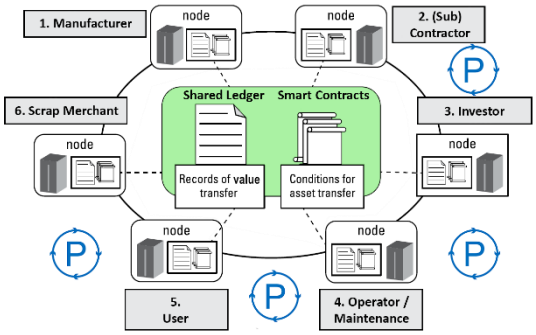


Figure 15. Circular ownership transfer (own illustration)

This organizational change can bring a first change for managerial processes internally and externally, to maximize the organizational opportunities, enabled through blockchain technology. Managerial roles of intermediates that are responsible for checking, rechecking and updating transactions flows, got to be questioned and relevant stakeholders can be integrated into their new roles with less intermediates.

Finally, these changes can enable opportunities for a circular building process where materials are traced throughout the lifecycle of a building. A building passport can contain material specifications, costs for creation and maintenance data. This information will simplify the reuse of materials after expiration of a building use. This means in the case of X-Decks, that, once a project is dissembled, instead of storing the materials, they can be made available directly for other projects on the blockchain and without any storage delays.

Considering the proposed blockchain-enabled organizational shift, it becomes clear that the 'Management levels' and pyramid structure of (Ad van Driel, 2016) in Figure 16 do not apply to the circular model in Figure 15, due to the distribution of risks and responsibilities of the 'cut out' middlemen to all remaining parties. This means that manufacturers, sub-contractors and RHDHV have to define upfront who is taking over certain operational, tactical and strategical risks.

Figure 16. Management levels: Real Estate as an investment (Ad van Driel, 2016)

Following up the idea of a decentralized process by directly connecting the manufacturers and suppliers to the investor, the following reorganization of the organigram (Figure 17) is derived for the X-Decks project.

A blockchain-enabled supply chain in the X-Decks case could 'substituted' out the developer and contractor from the hierarchical organigram and turn it into a more cooperative and circular one. The developer could be completely replaced by distributing its task through a shareholding system (described in Chapter 'X-Decks – Project Description') while, the contractor would be turned into an assembly operator who adds value by coordinating interfaces and logistics.

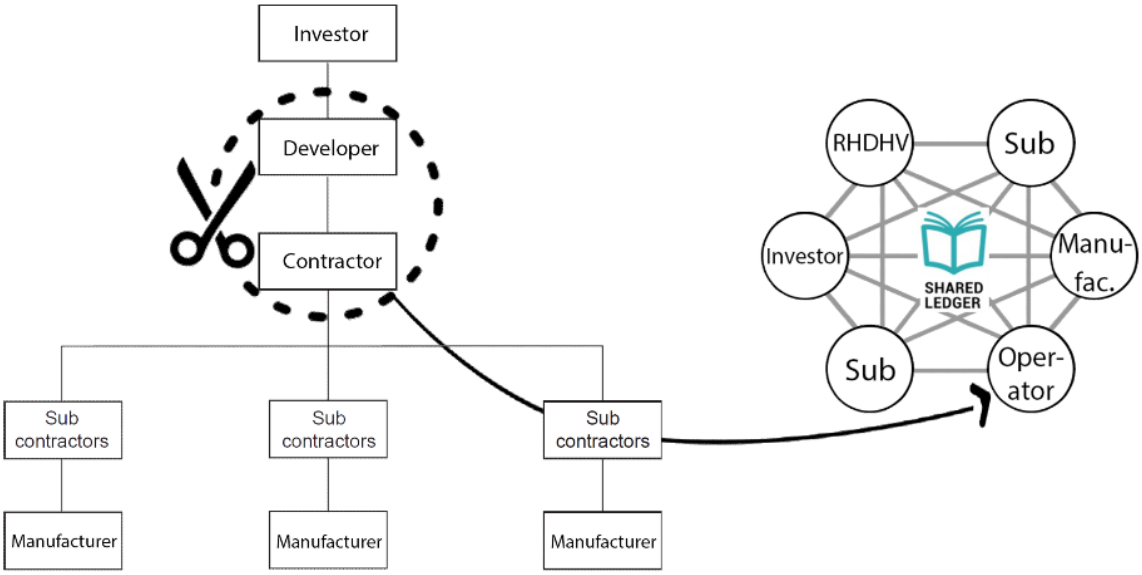


Figure 17. Reorganizing the hierarchic to a decentralized organigram (own illustration)

The 'empowerment' of the stakeholders, previously located on the lower end of the organigram, shall stimulate a more transparent and efficient supply chain enabled by blockchain technology.

Scenarios

The following chapter answer the third research question:

> *What are likely adoption scenarios for blockchain-based trading in the parking industry*?

The three scenarios estimate the time steps, technical progress and business logic that are necessary to operate the X-Decks project on a blockchain network.
The scenarios are categorized in near future, middle-term and long-term (Figure 18).

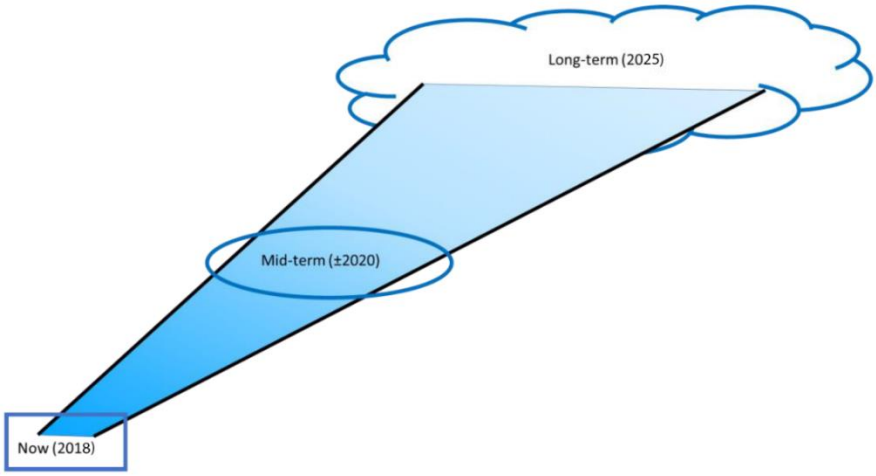


Figure 18. Three scenarios

Figure 19 represents a permissioned private blockchain network with trusted nodes. These nodes have full access to all data on the blockchain. Royal Haskoning appears twice in it; on the edge, in its traditional role as an engineering consultancy and in the middle, as a coordinating party. In the middle role is temporary and necessary because, in an early pilot study, transactions might not work as intended and there might be need for one party to coordinate and standardize the processes. It is not sure yet if Royal Haskoning is trusted by the other stakeholders to take this role over, possibly an IT company may support the setup.

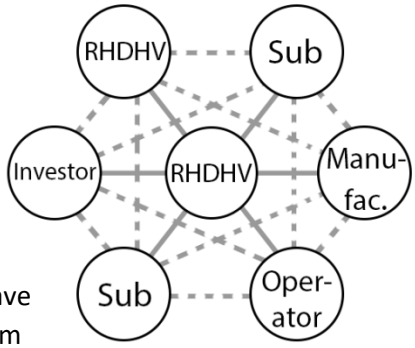


Figure 19. Scenario Now

Blockchains' main functionality is decentralisation, but companies have different interests, needs and perspectives on it, which might let them set their focus on e.g., transparency, efficiency, security etc. Hence, it is more important to find out about the companies' exact requests and meet their requirements. In Figure 19, blockchain technology has no benefit over a distributed database if it takes place in a trusted and private environment. However, it will be an essential backbone when the network will be extended to a blockchain with untrusted parties in the next scenario steps.

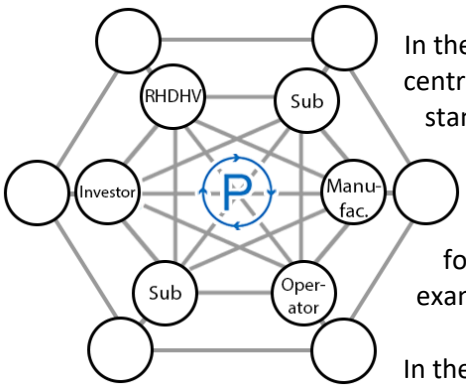


Figure 20. Scenario mid-term (2020)

In the mid-term scenario (Figure 20), the parking project moves to the centre. There is no need for an intermediate since once the standardized transaction templates are defined, they can be executed in a standardized and automated way with smart contracts. The second layer shall represent nodes that do not need full access to the network but access to a filtered version for the specific job that they commit to the parking project, for example plumbing, installing fire safety, etc.

In the third scenario (Figure 21), a public layer is added that extends the business to business network with public nodes. In this case, a public parking coin could be introduced, so that customers can digitally pay the parking fees and the coins can be directly distributed among the parties who hold shares in the system. Consequently, the Customer "C" moves to the middle of the network, in a more "symbolic" way. Furthermore, it is imaginable to offer individual investors the possibility to buy shares from the core consortium in the inner circle. In the third scenario, all parties involved in the X-Decks project get the chance to participate with their need or commitment on the blockchain over the whole life cycle of the building.

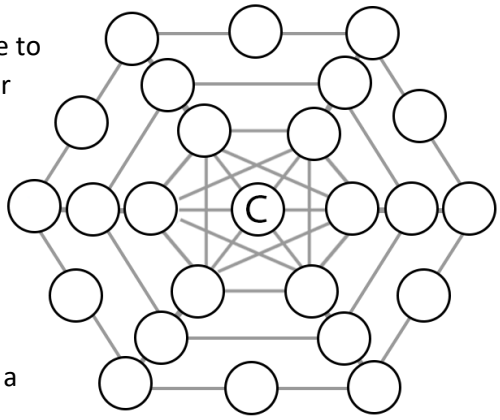


Figure 21. Scenario Long-term (from 2025)

Side remark

In discussion with Zhijie Ren, it became clear that there are limitations to cryptocurrencies since, even if they become mainstream, they will not merge. Consequently, it is not easy to use them in this system, a 2-way peg, as suggested in RSK, is one possibility but a self-sufficient parking system with its own coin is a better solution.

Scalability and a public chain are not a problem for the long-term scenario. Parking does not require a huge amount of data throughput, privacy, or complicated user scenarios. Also, it starts from a private blockchain (distributed database) and evolves to a public blockchain on a mid-term perspective.

Interviews

The following paragraph introduces the interviewees that are connected in different roles to the X-Decks project. This paragraph is followed by the results of the interviews and a discussion.

Stakeholders

Investor: Sander van Schijndel (Ontwikkelings **M**aatschappij **U**trecht**)**
A small, publicly financed investment and development advisory team that is interacting between public and commercial interests. The mission of OMU is to boost the development of mainly vacant office and industrial real estate that are unprofitable or too risky for most commercial developers. OMU is interested in X-Decks as a more flexible and affordable parking solution for newly developed urban areas in and around Utrecht.

Developer: Olaf Blaauw (Delta Development Group)
Independent consultant with multiple years of experience at Delta Development Group. Contributed to the Park 20|20 project especially in challenging currently common relationship models between developers, contractors and investors towards more sustainable buildings and areas from both, financial and managerial perspectives. “Cradle to cradle” and circularity are two important missions for Olaf Blaauw in the built environment. He was involved as an early advisor in the X-Decks project.

Advisor: Wouter van Twillert (C-Creators)
As an innovation manager for C-Creators, Wouter van Twillert is helping to change business processes towards a more circular way. He helped to implement circularity in the material and construction processes at an early stage in the X-Decks project.

Advisor: John Kraus (RHDHV)
Is a structural engineer and leading professional, formerly co-owner of an engineering firm that became part of DHV. Further, he is an advisor for the Park4All project, the predecessor of the X-Decks project.

Contractor: Kevin de Lange, Douwe van den Wall Bake (TBI)
TBI was interviewed as a potential assembly operator and coordinator for interfaces and logistics of the X-Decks project. The interview was conducted with Douwe van den Wall Bake, an innovation manager who works on new business models and sustainable solutions. Furthermore, Kevin de Lange represented TBI as a design and tender specialist.
Teun van Schijndel, a business and innovation developer at RHDHV, was also taking part at the TBI interview.

Manufacturer: Bas Meeuwissen (Metsä)
As a Sales Manager in the construction industry, Bas is an expert for high-tech wood construction products. Metsä is a potential manufacturer of the wooden flooring panels for X-Decks.

Interview Analysis

The interviews are examined in two ways. On the one side, there is the stakeholders' roles, responsibilities, business and information flows, as well as their innovative approaches and frictions they face in the building industry. On the other side their, (mis)conceptions and needs towards blockchain technology are received, resulting in limitations and opportunities for blockchain technology in general and for the X-Decks project. These two streams come together in the "Discussion", where the findings are related and evaluated with previous findings from the literature research. The discussion is later used to establish a blockchain based asset management framework.

Interview conduction

Six different stakeholders, involved in different phases and positions in the X-Decks project were interviewed. First, it was looked into the role of the stakeholder and its business and information flows (Table 2). After the analysis of the stakeholders' main role the focus is set on blockchain; firstly the interviewees general understanding of blockchain technology was studied and then X-Decks related blockchain business ideas. Based on the literature research, the case study of the X-Decks project and the scenarios a presentation was shown to every stakeholder (Appendix 4 - Presentation for first interviews). This presentation outlined the basics of blockchain technology, scenarios and the organizational innovation connected to the X-decks project (see chapter: First steps toward organizational innovation). After this short presentation, the "Blockchain enabled framework" questions shown in Table 2 were asked.

The interviews were semi-structured to offer flexibility for reactions and follow-up questions during the interview. The questions are asked in past tense to make the interviewee refer to executed projects and not ideal solutions 'how it should be'. The interview offers primarily qualitative data.

Topic	Interview Question
Role of Stakeholder	What was the main problem or need that is covered by your company's product or service (for the X-Decks project)?
Business and Information Flows	How were you contracted and paid – can you describe the process looking back at the last three projects you have worked on /the last three contracts that you signed with contractor / investor / developer / supplier / manufacturer? What kind of information and assets were stored, monitored and transferred, and which technologies were used to do so? Which partners were important for your own business model?
Blockchain technology	Were there any blockchain related projects at your company? If no: What do you know about blockchain technology? Did you heard about any applications (in the building industry)? Did you ever got the chance to invest materials or working hours to hold shares of a building project?
Blockchain enabled framework	What did you think of the suggested process via blockchain technology? What kind of barriers or roadblocks would you imagine in the blockchain space? Do you see other opportunities that can benefit from blockchain technology?

Table 2. Interview questions

Table 3 gives an overview of the Key Performance Indicators (see: KPI's) that are used to analyse the interviews. A "yes" or "no" indicates if the interviewee contributed to the relevant category.

Key Categories	Sub Categories	OMU	Delta	TBI	Metsä	RHDHV	C-Creators
Business and Information Flows	Role and Responsibilities of stakeholders	Yes	Yes	Yes	Yes	Yes	No
	Business and Information Flows	Yes	Yes	Yes	Yes	Yes	Yes
	Frictions	Yes	Yes	Yes	Yes	Yes	No
	Innovation	Yes	Yes	Yes	Yes	Yes	Yes
Blockchain technology & Scenarios	Conceptions / Expectations	Yes	Yes	Yes	Yes	Yes	Yes
	Misconceptions	Yes	No	No	No	Yes	Yes
	Needs	Yes	Yes	Yes	Yes	Yes	Yes
	Limitations	Yes	Yes	Yes	No	No	Yes
	Opportunities	Yes	Yes	Yes	Yes	Yes	Yes
	Replacement of middlemen	No	Yes	No	No	Yes	No

Table 3. Key Categories

Discussion

This chapter shall help to come one step closer to a Proof of Concept by discussing the interview data. The **main findings** from the interviews are categorized in Table 3 and can be found in "Appendix5 – Main findings interviews". The main findings shall bridge the gap between the raw data from the interviews, the KPIs and the following discussion. At the end of this chapter, new insights and further steps for a more detailed framework are drawn.

Business and Information flows

The following paragraph includes stakeholders' role and responsibilities, their business model, payment structures and information flows from the KPI's.

Role of stakeholders

Role of an investor
Pension funds often invest in real estate for long-term periods. They are one of the parties benefiting from circular building projects that can contribute to retain a higher residual value.
OMU, who appears as an investor in the X-Decks cosmos, invests usually for short-term periods of two to three years, similar to developers.

Role of a developer
Developers take the “highest risk of the entire process” and “the developer takes the risks that the investor is not willing to take”, says Olaf Blaauw from Delta. The timeframe is usually kept short and projects are developed in two to three years.

Role of a contractor
TBI is a “shop with different flowers”. As a contractor, they fulfil multiple tasks with different subsidiaries within the company. In only 10% of the cases, they appear as a combination of a contractor and developer.
Their business model is to invest in a project and get the money back as fast as possible to use it as capacities for new projects.
TBI describes itself as a party that is needed in the building industry as a robust player. When subcontractors fail under their coordination, TBI has the capacity to absorb that, which is crucial in today’s building business.

Role of a manufacturer
As a manufacturer, Metsä represents the interests of its shareholders; forest owners. Prefabrication and adding value to raw materials to create higher margins for their products are at the core of their interest. This also includes moving towards the role of a supplier and being less involved in the actual construction of projects. There are first initiatives within the company towards circularity but not in cooperation with external companies yet.
During the interview with TBI, it became clear that the more complex a manufacturers’ product is, the more he moves towards a position of a coordinating party, similar to a contractor, e.g. when it comes to coordinate the supply chain of a complex facade element.

Role of government and public parties
The municipality and aldermen play an important role especially when it comes to unconventional solutions. Regulations can be changed to comprehend innovative approaches, “this is crucial for the project Park 20|20”, says Olaf Blaauw. It is also of high interest of OMU to make sure that government and private sector work together seamlessly.
This is relevant for X-Decks because the current political agenda supports the reduction of parking space in certain redevelopment projects and wants to provide mobility with less focus on cars. Also, OMU works on projects where the number of car parking spaces is reduced because there will be less demand. Developers, as well as the municipality, want to lower the risk of building for vacancy. Underground parking spaces are especially expensive and inflexible. As Sander van Schijndel says “a reduction of parking spaces is required by policies as well as well as by society”.

Moving towards recurrent business models
Metsä is actively investing in wood prefabrication companies to extend their business segments further into the refinement process of wood and profit from holdings of these companies. Furthermore, this shall not only help to acquire single projects but to get a constant project stream. Similarly, RHDHV is exploring new business models by moving from one-off invoices to service-based, recurring business models like X-Decks or Fastlane.

Park4All (predecessor of X-Decks)
Parking decks have been acquired directly by the customer, there was no external or upfront financing necessary, although there is support of a private investor who is involved with 15 million Euro, but “that money was not needed by now” says John Kraus from RHDHV.

Collaboration between stakeholders
For Delta, access to the contractors' network of manufacturers and suppliers is crucial to enable collaborative design. This collaboration needs to start at an early design stage, before anything is manufactured or tendered. C-Creators support this argumentation; co-creation and joint ventures are becoming an alternative to subcontracting – especially when it comes to new and innovative solutions. This cooperation can help to reduce failure costs that make up to 20% of the building costs.

Information flows
For Delta, the main source of information is handled with BIM. There is definitely a need to derive information in a spreadsheet from BIM for asset management services.
OMU is correcting budgets, setting up cost analyses and site surveying for external parties, this is done with MS Excel. Also Dropbox is used to share documents but Sander van Schijndel calls this way of working rather old fashioned in which paper and digital contracts are stored in a Dropbox at OMU.

John Kraus from RHDHV says that currently financial information is managed in MS Excel sheets and contracts are handled by e-mail or on paper, but there are first initiatives to move these processes to a cloud service at RHDHV. Physical assets and construction materials are stored at a contractor and there is currently no access or tracking possible.
Summarizing, it can be said that there is a slow transition happening towards cloud services. It is easier to share documents and manage back-ups there. However, information is still organized in separate files as isolated information. The Geographic Information System (GIS) presented by OMU was the most advanced approach mentioned during the interviews. It connects information that I collected during interviews with clients and within the working environment of the province of Utrecht. Collaborative digital asset management as proposed in this thesis was new for all parties.

Innovation & Fictions

Innovation

Parking as a service and circularity
A switch from product to service thinking is especially present at Delta, RHDHV and OMU. Blaauw states that construction methods and technical solutions are already available to achieve circularity but it is mainly about **implementing and incentivising circularity in the financial structures of the building industry**. This also applies to the Park4All project, where the technical solutions are available: ''in our case, all parties collect the materials themselves at the end of the lifecycle'', says John Kraus, but the financial incentives to stimulate investors and tender procedures towards more circularity are not there yet.
All parties that have been interviewed have an agenda towards circularity. Delta and C-Creators have it deeply implemented in their business model, RHDHV guides their clients actively in a more sustainable and circular direction.
Olaf Blaauw states "It is not just about looking into circularity and modular design for the sake of flexibility but to increase the value of the property." The time frame for circular projects plays also an important role: "anything that can be arranged from 3-15years is doable in today's climate". Since real estate and also conventional parking spaces are usually built for a longer operation time, implementation of circular processes gets more complex.

Circularity and products as a service go hand in hand. Circularity in the built environment requires to document and maintain building components over its whole life cycle. This collection of data can open new business opportunities for the data collector since; the denser the web of technical, financial and operational data is, the better the evaluation, operation and reuse of the building.
For X-Decks, parking as a service and circularity means that the parking decks are assembled where demand is and removed or decreased in size when the demand lowers.
OMU likes the idea of "buying flexibility" for areas where they do not know how the parking demand will develop.
Furthermore, services can be added beyond the technical operation and maintenance of the building. RHDHV and TBI see here market potential when looking at projects like Sidewalk Labs. Services can be directly targeted at the customer of the parking garage and provide them a car wash, toilet, kiosk or charging of electric cars directly on the spot.

Transparency
When data is digitalized, collected and interconnected it can be shared easier and, consequently, transparency becomes an option. Transparency is an important mean to establish trust between collaborating parties. As mentioned before, a stronger collaboration can lead to risk budget reduction in the building process. But, there are also limits to transparency: scarce information empowers a company and its business model – if everything is completely transparent, companies weaken their business model. Therefore, it has to be found a **medium between opening silos, that hinder efficient collaboration in the building industry and preserving the business models of the relevant stakeholder**. In principle, transparency is a mean to increase reliability and reduce risks during the building process.
RHDHV wants to design an asset management process between the core consortium of X-Decks as transparent as possible. With time and experience, it will become clear how much transparency can be efficiently provided to external stakeholders outside of the core consortium.

Tendering
Olaf Blaauw remarks that it is crucial to change and improve the tendering process in the building industry; "[trades] are racing for the bottom of quality where they barely meet the requirements for the lowest possible price level, and this leads to a bad product. Delta is actively changing this routine by not tendering for the lowest price but with a fixed budget for a building and a fixed price that it can be sold to an investor, and so fixed profit margins are offered to all stakeholders. Transparency and trust are here very important!"

Strive for new business models
Although, RHDHV and Delta have common goals and interests, RHDHV competes with Delta with the X-Decks project by taking over the developer role themselves.
The other parties play a more supportive role in the X-Decks project, but they are still rather distant when it comes to changing their processes towards a model where they hold shares and risks themselves.

Beyond that, RHDHV appears in the conducted interviews outside of their classical role of an engineering consultancy since John Kraus and Teun van Schijndel are pushing towards new business models within RHDHV. Kevin de Lange from TBI points out dependencies of RHDHV towards contractors: "A company like RHDHV, they always need a contractor like TBI. When there is something going wrong, they [TBI] have the capacity to absorb." this is argued by Teun van Schijndel by the new approach of X-Decks "**You can also look at an ecosystem to have capacity or capacity as a middlemen instead of a system**."

This is an interesting point that summarizes what is intended with the blockchain network for the X-Decks project; **distributing liabilities to an ecosystem of stakeholders to create an equally powerful party that is currently represented by developers and contractors. By linking smaller parties and their competence together, capacity and resilience are created and secured by a trustable system like blockchain.**
Taking a step back, it can be said that this capacity discussion is more important when the organizational structure of X-Decks will be applied to more complex building typologies. In the case of X-Decks, there are no long-term commitment risks like in most real estate that is built on a 20-50 years perspective.

Frictions

Collaborations between stakeholders
When mentioning during the interviews to create a direct connection between the manufacturers, sub-contractors and investors, it was noted by nearly all parties that **subcontractors and manufacturers have often a limited overview of the whole building process – they usually give a guarantee just for their very own contribution. It will be difficult to incentivize their behaviour to contribute to the "bigger picture" of the building process.** The same applies to investors who usually have limited knowledge about the building process.
A blockchain enabled asset management tool has to contemplate these road blocks and make use of data that usually gets lost from the side of manufacturers and subcontractors. Furthermore, this data has to be accessible to investors that use of it for an in-depth evaluation of their assets, which are currently based on rough estimations. Sander van Schijndel, in the role of an investor, confirms it and shows interest in this opportunity on a blockchain network.

Frictions at Park4All - Willingness to lease
John Kraus gave deeper insights into the Park4All project during the interview. First attempts were made towards leasing parking space but, in the last three projects, just one was leased. In the other two, it was decided to sell and buy back the parking structure in five to ten years for an upfront determined price. Leasing, common practice in the office market, is not common in the parking marking yet. Although leasing is crucial to stimulate cooperation between the stakeholders who build and operate the project, **when the project is sold the opportunity to create stronger collaboration and shares for the stakeholders is lost.**
Furthermore, the parties in the background can 'make or break' the image of the product. "You have dependency on certain partners, but you are not in the lead for these partners." Controlling the ends is one of the main challenges. On the one hand, you give responsibility to a contractor who coordinates processes for you. On the other hand you lose control over quality standards that define the product you are finally selling.
Shares at Park4All – Willingness to acquire shares
First attempts to offer manufacturers shares in a project were answered with scepticism – it is not really in their competencies to handle development and operation processes of a building. TBI says "And when you say [X-Decks] will remain my ownership like the construction and the floors then this hinders our processes". One manufacturer that was interested asked for a certain percentage of shares upfront, which would lead Park4All to take development risks to guarantee a certain percentage of shares upfront! This was not in the interest of Park4All, but to distribute the development and operation risks and revenues from the beginning of the project.

Organizational silos

The hypothesis of the problem statement that organizational silos hinder cooperation in the building industry has been confirmed by most interviewees, just the position of the organizational silos differs from the particular perspective of the stakeholder. RHDHV sees the silos at the contractor and developer, since these parties are blocking access to more transparent processes and recurring business models. TBI, in contrast, sees organizational silos within their own company because there are different business models of the different subsidiary companies within TBI. That hinders cooperation, transparency and setting common incentives for a project. OMU experiences a similar roadblock when it comes to introducing the X-Decks project to their superior instance – the province of Utrecht. The province judges the work of OMU by revenues of transformed square meters. Service based business concepts like X-Decks are not considered in the standardized evaluation. Furthermore, TBI experiences enclosure of information at a manufacturer level. When the order situation is high for a manufacturer, they are in the position of control who they sell their products to and for what price. If the economic situation is bad the manufacturer might be forced to sell products for a very low profit margin. In this case, transparency would not help to increase reliability, if a manufacturer does not have the capacity to deliver a certain product, the system has to be so flexible to come back to a different manufacturer who has the needed capacities.

This is interesting for the X-Decks project because it has to compete with the rising and falling economic cycles in the building industry. In low economic times, it might not be a problem, but when the demand for building projects is high, like it is currently the case, the profit margins, especially for the external stakeholders, have to be attractive enough to stay involved. It has be found a balance between binding stakeholders on long-term perspective, to have reliable partners and a routine work flow, and interchanging stakeholders when possible, to make use of resources that are not available by the core consortium.

Failure costs

Currently, a reservation for failure costs of 20% is usual. With collaborative design, this percentage can be lowered. “So practically we aim for 7-8% to have 12% of margin to be distributed among all those players who make [collaborative building] possible.” says Olaf Blaauw.
Also, in the interview with TBI, it was mentioned that a system where 20% of the total costs is spent for risk management is not a really logical model, but it is the best one, it could be thought of for now.

Residual value

Residual value is not considered by investors, and it is often just a nice bonus when the building is sold. The risk profile is not fully understood through a lack of documentation and cooperation. “[Developers] are taking care of financing the building process, you take a return on investment on the financing, process not on the actual object - this is where it goes wrong!”, says Olaf Blaauw and ‘’exploiting residual value and exploiting residual functional value, not so much material value as in means to finance upfront investments. So, you get to a **total costs use-based exploitation systems’’**. This approach is interfering with the ideas mentioned above under “collaboration between stakeholders” where an inclusion of the manufacturers and sub-contractors can contribute to a more complete risk profile of anything that goes into a building and how it will retain its residual value over the course of time. This is currently not very well understood.

Conservatism
Conservatism was mentioned independently by multiple interviewees as a friction within the building industry. From a mentality that answers to new approaches with “This is how we always have done it!” reported by Delta to OMU where most employees like to work rather old fashioned – in their routine way. Also Bas Meuewissen from Metsä reports that the way to deal with costumers is rather traditional, new solutions are often too costly and faint with time. These three examples show that parties in the building industry are rather shy to innovate and prefer to adopt proven concepts. Especially when it comes to experimental approaches like blockchain technology.

Mutable data
Information usually does not build upon each other. Delta and RHDHV agree both on this point. It is even certain that information will divert over time when not properly documented, says Olaf Blaauw. It was already tried in many projects but it never worked out seamless. This can even be an entrance door for fraud, says John Kraus.

Financing structures the main problem
As mentioned in the chapter “Innovation” under “parking as a service”, technical solutions can be currently solved easier than the financing structures. Olaf Blaauw says “you can build something that is totally circular which retains maximal functional value, which has enclosed loop systems for electricity, water, whatever…but **we will not pay for it because, although this pays itself through a lower total cost of use, because of the investment structures we take, we do not do it!** So, the main snag is not that, but the fact that the financing underlying it is not properly done.“ This is one of the major frictions when it comes to implementing a circular concept like X-Decks to the currently common business models of the interested stakeholders, as well as the potential clients.

Blockchain

As high as the interest and curiosity about blockchain, as high is the scepticism towards this new technology. This discussion shall help to take a stand on knowledge that is currently common among experts in the built environment.

Conceptions and Expectations

Presenting blockchain technology in connection with the built environment is new for most interviewees. “Torch” is a project that was heard of, but it does not take place in the building or construction phase of a project. This is why most conceptions and expectations around blockchain technology are centred in general aspects or in connection with financial applications like Bitcoin.
A conception and expectation mentioned by most interviewees was the distribution of control over multiple parties and the unalienable aspect of blockchain technology.
TBI goes even one step further and says that blockchain “in my first opinion, is not very valuable to us”.
Also Wouter van Twillert has second thoughts that such an immature technology is “probably not user-friendly” and is currently treated as a silver bullet with no furnished proof.

Misconceptions

Centralization/Automatization
"I think you always need a coordinating party – I think it is an illusion that the coordinating party in the middle can be replaced. It can be made easier or more automated.", said Teun van Schnijndel, referencing to the second step of the scenarios. This is a misconception and is not applicable when it comes to a blockchain network. Bitcoin is a good example to proof the opposite. From a business perspective, it is favourable to keep the coordination of the network in the hands of a few stakeholders that have full control. However, time will show if that might change and if the sharing economy can be also be run only by costumers. Nonetheless for the case of X-Decks, judged from this point of time, one party has to start to set up this process.

Transparency
It was mentioned by Wouter van Willert that blockchain technology is a good solution when transparency is the most important criteria. This statement cannot be confirmed in its broad phrasing. Approaches like Hyperledger Fabric are providing confidentiality or even anonymity in the case of ZCash with the means of blockchain technology. Although it is an intention of this thesis to create more transparency in the building process, it is not an obligation on a blockchain network. Blockchain helps to decentralize processes, in first instance.

Long term commitment
In the interview with OMU, it became clear that "A long term engagement of more than 5 years will be very difficult! That is the biggest threat for OMU in the blockchain". As explained in the paragraph "1st Model & 2nd Model", OMU can still join the blockchain as a member of the core consortium or external B2B partner with no timely restrictions.

Energy consumption
A final misconception is that blockchains need a vast amount of energy to be operated. This applies to Bitcoin and the Proof of Work consensus algorithm but there are promising solutions for public blockchains to solve this issue, like Tangle or Hashgraph (Schueffel, 2018). The case of X-Decks is not affected by a vast energy consumption, since a private blockchain consumes just a fraction of the energy consumed by a public one.

Needs

As the extensive friction section above confirms, there are many needs that can be possibly improved with blockchain technology.

In first instance, an improvement of trust between stakeholders and more transparent processes are needed by every stakeholder. Organizational silos are too predominant in the built environment, in the case of TBI even within the structures of the company. Blockchain technology is promising here a tool for a seamless documentation that makes data available even if one party goes bankrupt within the building process (Delta) or as Sander van Schijndel says: "make sure that our relevant risks could be better and easier analysed than it is the case right now".

As mentioned before, TBI sees the potential to improve internal structures with blockchain technology, so that common incentives can be created among the differing business models within the company. Once this internal issue is solved, transparency can be better communicated and carried out to external stakeholders.

Also, Olaf Blaauw from Delta sees a possible link between internal and external processes. By connecting BIM and Madaster blockchain would be very helpful as “, a way to combine datasets that [they] become immutable and that they have a common core language to rely on.”

Summarizing, it can be said that blockchain technology connects best with the need for more trust and transparency, aligning silos internally and externally by increasing interoperability between differing stakeholders and business divisions.

Limitations

Stakeholder complexity
Limitations can develop into risks if not properly handled and a blockchain network is worthless, if it does not hold on to its promises. Therefore, the added value of the system has to be evident and exploitable as early in the process as possible. Within a core consortium of dedicated shareholders who document and trade their assets with each other, the added value is obvious. When it comes to involving manufacturers and subcontractors, it gets more complex. They play a crucial role to scale up the network and collect a denser web of information, but they might not be interested to commit to the system. Which incentives are there for them to join the network and to compensate for the additional effort that has to be taken to join the blockchain? The simplest solution would be to offer a monetary compensation to digitalize their contributions on the blockchain.

Scalability
Another limitation is the general applicability of the X-Decks case. It is seen by all parties as the right project to start with as a prototype but, on the other side, it is doubted how transferable and scalable the insights will be for more complex projects. Olaf Blaauw says: “with X-Decks it is easy with 4-5players. More complex projects will require a developer again”. There are similar insights during the interview with TBI: “with the parking space, this might work but, for an office building in Zuidas I cannot imagine that, to create a manageable system with lower investment costs.” These quotations also justify the intention of RHDHV to use the X-Decks case as an experimental case study that, if successful, it needs further development to be applied for more complex building typologies and processes.

Risk distribution / liabilities
“*How is this risk management distributed in the new model*?” is asked by Olaf Blaauw and it is an appropriate question. Risk distribution is not fully detailed within the capacity of this research yet. In the asset management framework (see: “Blockchain enabled asset management framework”), roles and processes are better defined than in the scenarios, presented during the interviews. An open questions is; who is taking over which exact liabilities in case something goes wrong in the process? This is a topic for further research, detailing the contractual relations in the asset management framework, possibly in combination with smart contracts.

Opportunities

The predominat opportunity seen in blockchain technology is to create a generic propose tool as a “value chain management optimization to create transparency on the entire value chain with all the stakeholders involved.”, says Wouter van Twillert. This is truly new since values and assets are commonly traded through middlemen. Olaf Blaauw specifies value trading from his perspective of a

developer; understanding the risk profile of anything that goes into a building and how it will retain its residual value over the course of time is important for him. His perspective aims for a better evaluation through immutable data collection: “I am trying to get to that the perceived risk of having a return on investment which might be different from how we envision it today because you do not know the actual development of value of certain inbuilt objects or in a car or refrigerator, and it will evolve over time. It relies therefore heavily on the quality of the information you have – and this is where blockchain comes in.”
Ultimately, this can lead to a risk budget reduction in the building process and a more efficient system with higher profit margins or better building quality.

Also, John Kraus sees opportunities in data collection when the project volume of Park4All is rising. It will be desirable to digitalize and automate the assets flows to control which materials are used or where they are stored and to get access to contractual relations in specific locations. For this purpose, it is desired to digitalize materials, working hours and money into virtual shares.

In this sense, Sander van Schijndel sees an upcoming business opportunity for RHDHV; “blockchain seems to be a good way to formalize the ambition of RHDHV to move from hourly-paid services to a more trusted advisor who distributes the risks between the parties in the chain and takes out the hierarchy.” This is very much in line with the business innovation department of RHDHV.

Lastly, in the interview with TBI it was mentioned that a reorganization of the hierarchical organigram into a circular one (“First steps toward organizational innovation”), which is basically a representation of contractual relations, can lead to a reduction to just “one contract”. This “one contract” can be understood as a system that serves as a single source of truth on the blockchain. Also, John Kraus shares this perspective by saying that lawyers and notaries are currently needed to monitor the entire system of contracts. Blockchain technology can enable more consistency and transparency on how things are working in the rest of the chain.

Replacement of middlemen

Replacement of middlemen or intermediates is at the core of blockchain technology. Therefore, it is important to identify potential middlemen in the built environment and in the X-Decks case.

Most input was given here by John Kraus from RHDHV. Related to the role of banks he said “if we want to do it in a new way, a new role for a bank is to be the financial engine behind the system. But you do not really need a bank anymore, but a financier”. This statement connects with one from Olaf Blaauw: “You would not require a developer in the first place, even in the existing system if it were not for the trust issue”. As developers often combine investment services on their role, Olaf mentions here an important point: “the trust issue”. John sees this trust taken over by RHDVH in the case of X-Decks and goes even one step further: “The contractor and developer have to be cut out. They want to hold back these kind of systems. Today, the developer and contractor are the powerful parties. They understand that their role will be less important when we work like suggested”. This confirms once again that RHDHV wants to partly take over liabilities by themselves and partly distribute them in the new organizational structure of X-Decks by e.g. turning the contractor into an assembly operator, coordinating interfaces and logistics.

This opens an interesting discussion;

Cooperating with bigger players in the building industry leads to more security, possibly long-term commitment and capacity to build up a blockchain network from scratch. On the other hand, such

guarantees come with costs, the bigger parties might tend to act as middlemen and hinder the creation of a system that might affect their own business model or role (Douwe van den Wall Bake: “But that is the classical thinking. When you start working with these parties”). So, they might set an early end to the decentralization possibilities. However, smaller players might not have these restrictions but might be limited in resources to set up a running system and have a sufficient reputation and business network to convince new parties to join the system.

A possible approach for this issue is to lease the services from bigger companies and link financial means of investors with the innovation drive of smaller players.

Conclusions

The interviews gave essential insights in validating the problem statement and illustrating different perspectives of potential stakeholders in the X-Decks project. Furthermore, feedback was gathered about the scenarios and what has to be considered when creating a more detailed framework as well as formulating a Proof of Concept.

New insights were:

- Documentation of financial, operational and managerial data between stakeholders is not happening yet – there are first initiatives in the operation stage but none from the beginning of the building process.

- Reduction of the risk budget during the building process and exploitation of new business models are the main motivations to use technological innovation.

- Reservation towards actively developing a prototype and holding shares in X-Decks, which might be caused by the conduction of interviews at an early stage of the research, just with the scenarios available.

- There is a need for more transparency to overcome organizational silos, or, more precisely, to find a balance between preserving silos to run a business model and opening it up to enhance cooperation and data collection.

- In the scenarios, it was not clear what to trade and on which processes and time to focus during the building process. During the interviews, it became clear to make a generic purpose tool for asset trading that offers interfaces to connect with additional services in the future.

Figure 22 shows what the findings from the interviews mean for the B2B stakeholders in the scenarios:

1. Give parties access to the blockchain as an auditor like OMU.
2. Give parties just access to the operational information on the blockchain.
3. Let parties easily join and leave the system in all layers and possibly with low time restrictions.

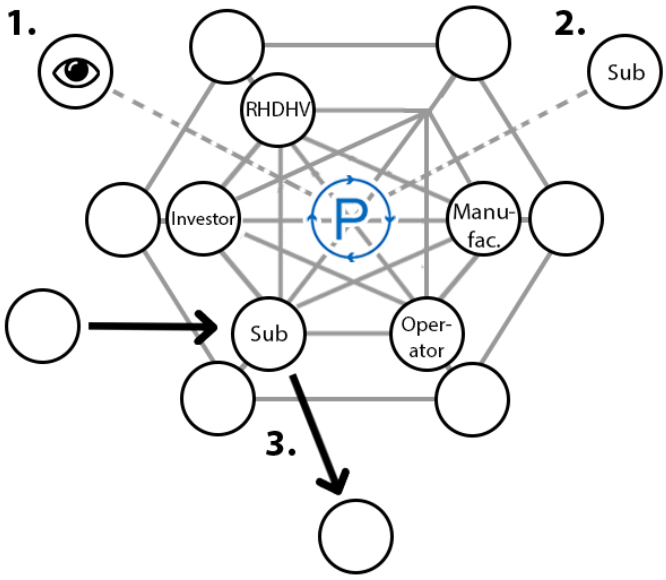


Figure 22. Insights from interviews applied to B2B scenario (own illustration)

Preliminary input for the framework

During processing the interviews the leasing and sharing model was further detailed.

The current business model of the Park4All project, derived from the interview with John Kraus, is mainly based on selling and buying back the parking structure. Problematic is that when selling the project, the opportunity is lost to create a stronger collaboration between the stakeholders.

Another friction of the Park4All project is visible in an excel calculation tool created by RHDHV. It serves as a prediction tool for potential costs and revenues over time spans from five to 20 years. Using the tool it becomes clear that in the current situation, a Park4All garage is not profitable under an operation period of three years, when considering the investment costs and potential revenues.

This tool can be used for a further in-depth analysis of the technical and financial specifications to predict assets and their value better. Also the research of (Hassan, 2018) gives further insights on financial data prediction.

Lease model

To improve the status quo, the circular concept of X-Decks can be enhanced through a lease model. The core consortium agrees with external stakeholders on a lease contract for their services. Consequently, the core consortium guarantees a steady income for the external stakeholder by taking over possible development risk. This project based approach is suitable for a project like X-Decks with not too complex interfaces between few stakeholders. The external stakeholders can focus on creating the optimum for their specific product and have an incentive in making their product better to keep maintenance during the lease low.

Share model

An increase of commitment and own risk is required for adoption of the share model. Here, commitments like working hours, materials, land etc. to the building project are turned into shares.

Gains as well as losses are directly distributed between the shareholders. The core consortium can offer external stakeholders to pay them off traditionally or enter a lease contract as described above. The members of the core consortium that pay off the external stakeholders take over the according shares for their commitment.

Figure 23 describes a scenario how the shares could be distributed between the members of the core consortium during the lifecycle of a X-Decks project. The pie diagrams in the upper part describe the shares that the core consortium members could own during different phases in the project. The lower part describes the path of a physical asset and its digital twin throughout the building lifecycle. The amount of stakeholders holding shares in the X-Decks project hypothetically increases over its lifecycle. Due to the rising amount of trades the shares are split between six parties when the X-Decks project goes into operation. Again, hypothetically the share of the operator rises during the exploitation phase of the X-Decks parking space. Since the operator will most probably have the highest expenses during the operation of the building, this explains the rising amount of shares from the fourth to the fifth pie chart. At the end of the exploitation phase the materials stay in the ownership of just few stakeholders who store and reuse it for the next project.
During the whole lifecycle data of the assets like value, condition of material, location…are added to the digital twin on the blockchain and can be used e.g. for predictive maintenance or an evaluation for the according shares and building value.

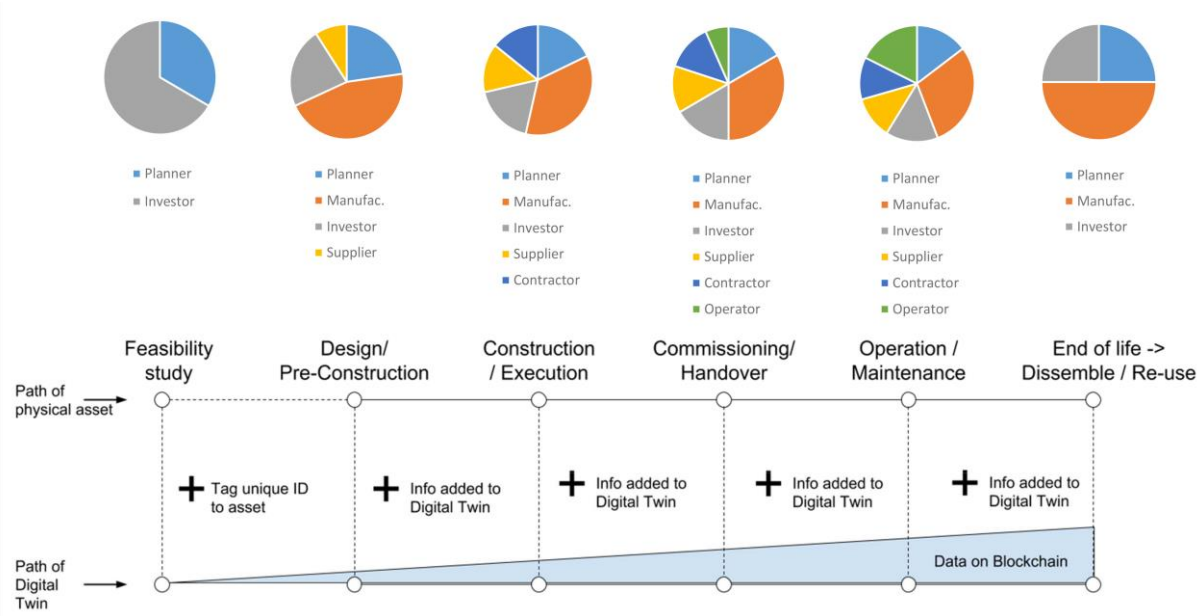


Figure 23. Shares model/Building passport/construction management.

In a more general context the proposed process in Figure 23 can tackle current weak points in supply chain management. Weak points occur where there are multiple enterprise resource planning systems in use across organizations. Data doesn't flow well through the handshakes or interface points between systems. These weak points usually happen during transference of ownership, or change in status between two parties. Visibility is limited at the hand-off points of funds, raw materials, components, or finished products. This lack of transparency is often intentional, as companies don't want to expose their competitive advantages (e.g., an inexpensive supplier who delivers quality products on time). Additionally, a company could be cut out of a supply chain if members start transacting directly with that company's suppliers.

Answering the fourth sub question

What roles can current market parties play in such a system?

As mentioned in the “Scenarios”, the roles are basically separated in three layers: a core consortium, an external business to business layer and a public layer of consumers and investors.

The core consortium:
The visualization in with an investor, operator, RHDHV as initiator and engineering consultant, manufacturer and subcontractor is just an assumption and can change according to the willingness of the stakeholders to hold shares and exchange data collectively. The stakeholders are free to move between the first and the second layer, according to the contractual relations they want to choose. During the interviews, it was mentioned that RHDHV intends to change the role of the contractor to an assembly operator that is coordinating interfaces and logistics.
Contemplating the role of RHDHV, in the beginning, when setting up the processes, RHDHV comes closest to the role of a developer but it changes with time from a central party to an equal role in the core consortium.

From the interviews, it became clear that OMU possibly wants access to the system as an auditor to overlook the process even if they are not actively investing. This option might be given to public parties as potential adopters of X-Decks, who support the project to form a legislative perspective.

External B2B layer
In this layer, first contact with the X-Decks project is probably made by most parties in the built environment. It requires little more commitment than currently common in the building sector. All parties who want to be paid one-off or enter a leasing contract for their commitment are located here. Most interviewees hint that this would be where they join the system at first.

Public layer
Shall include individual investors and consumers to X-Decks. The investors get partly access to financial data without the voting right of the core consortium members.

Summarizing, it can be said ,when looking at Figure 23, that the biggest impact and challenge for the roles of the stakeholders is that e.g. a planner can get the possibility to stay involved as an owner and decision maker during the whole building lifecycle.

Blockchain enabled asset management framework

The framework is at the core of this thesis research. It combines the findings from literature research with the specifications of the X-Decks project and the input from the interviews. The framework creates a “bigger picture” of processes that are relevant to establish a scalable blockchain prototype for asset management in the X-Decks case. The framework is separated in three models that build upon the previously discussed three scenarios (Chapter “Scenarios”). Every model is explained in three steps; the first step shows the processes, the second illustrates the processes with an example and the third step explains the process on the blockchain network.

1st Model

Figure 24 is an advancement of the first scenario in the chapter “Scenarios”.
It is conceived for a core consortium of the X-Decks project. Only stakeholders who want to hold shares are eligible to join. The flow starts with a stakeholder of the core consortium proposing an asset. This asset can represent working hours, materials or land as a digital twin. This proposition is validated by the other stakeholders with a simple manual voting consensus algorithm. If the stakeholders decline the asset proposition, it has to be proposed again. If the proposed asset gets accepted by all stakeholders, it is logged on the blockchain. Once the asset is registered on the blockchain, it is turned into a share. In case a stakeholder wants to step out of the core consortium, reduce its amount of shares or change their asset value/attributes this has to be proposed again.

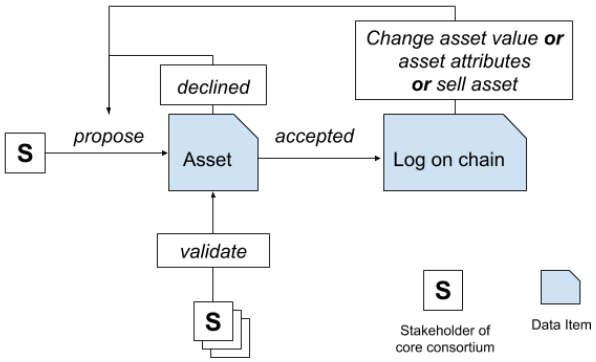


Figure 24. Core consortium asset management process flow

Figure 25 illustrates the process described above with an example:
We assume that OMU, Metsä, TBI and RHDHV are part the core consortium. OMU proposes land as an asset to the other stakeholders. The proposition comes with technical and financial specifications (see Figure 25). Metsä, TBI and RHDHV all have to agree to these specifications. Once they accept, the proposition is turned into a share of X-Decks. In this example the upfront estimated costs for the whole project are 3.5 million Euro which results in a 20% share for OMU.
Later in time, the land gets reduced due to lowering demand on the parking site. This leads to a new proposition, which will lower the asset value and share of OMU.

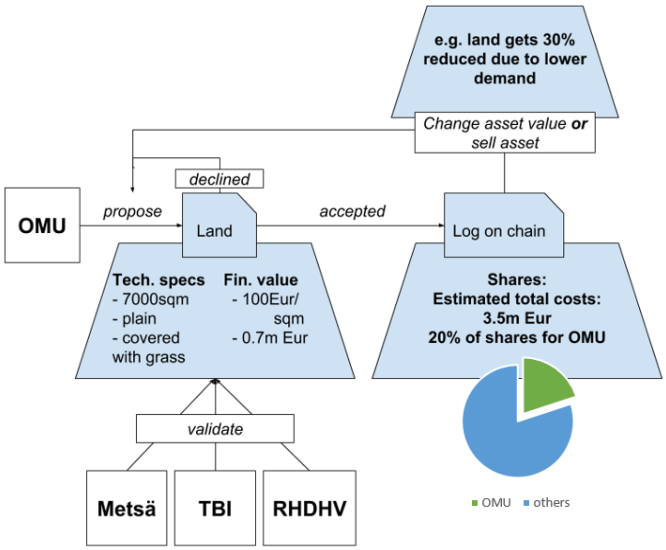


Figure 25. Illustrated example of core consortium asset management process flow

Figure 26 describes the process on a permissioned, private blockchain network. Each block consists of one or more transactions which have to be validated by the core consortium through manual voting. Every party of the core consortium has to agree to a proposed transaction before it gets processed to the blockchain. The data of a block is hashed together with the hash of the previous block to form a unique string. This unique string guarantees that any manipulation of data within the block can be detected and gets published to the network.

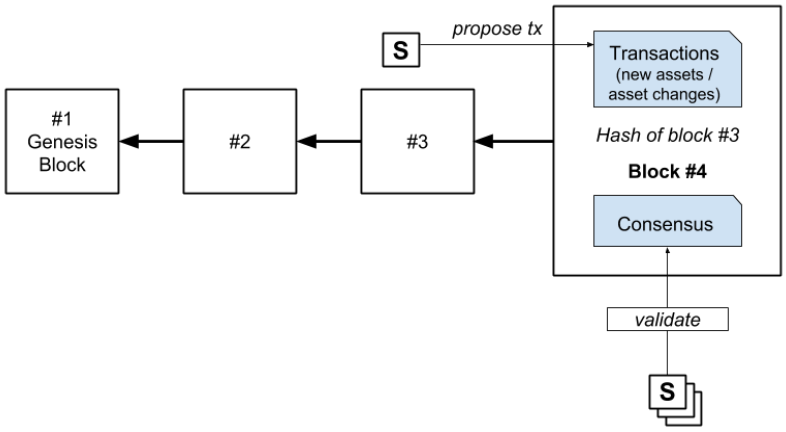


Figure 26. Core consortium asset management flow on the blockchain

On one side the first model shows that the blockchain can store and transfer monetary value. On the other side, it can also store and change asset information, which can be used to maintain a building passport to make better predications about the condition and value of the building.

A major restriction of this 1st model is that just the core consortium has access to the blockchain. This limits the distribution and immutability of the system. Furthermore, tasks that are executed by external stakeholders have to be updated manually by the core consortium, which can lead to double work.

2nd Model

The major difference between the first and the second model (Figure 27) is that external business to business stakeholders get access to the network. External stakeholders are temporarily involved in the X-Decks project or do not want to hold shares, like members of the core consortium. The process is, in principle, the same as in the first model; the external stakeholders can propose assets, which are validated by the core consortium. Once an asset is accepted, it gets logged on the chain. The external stakeholders have access to operational information and the core consortium has full access to operational and financial information. Different user interfaces secure that members of the core consortium can sell assets, which is not necessary for the external stakeholders. Change of asset values and attributes can be proposed by both parties.

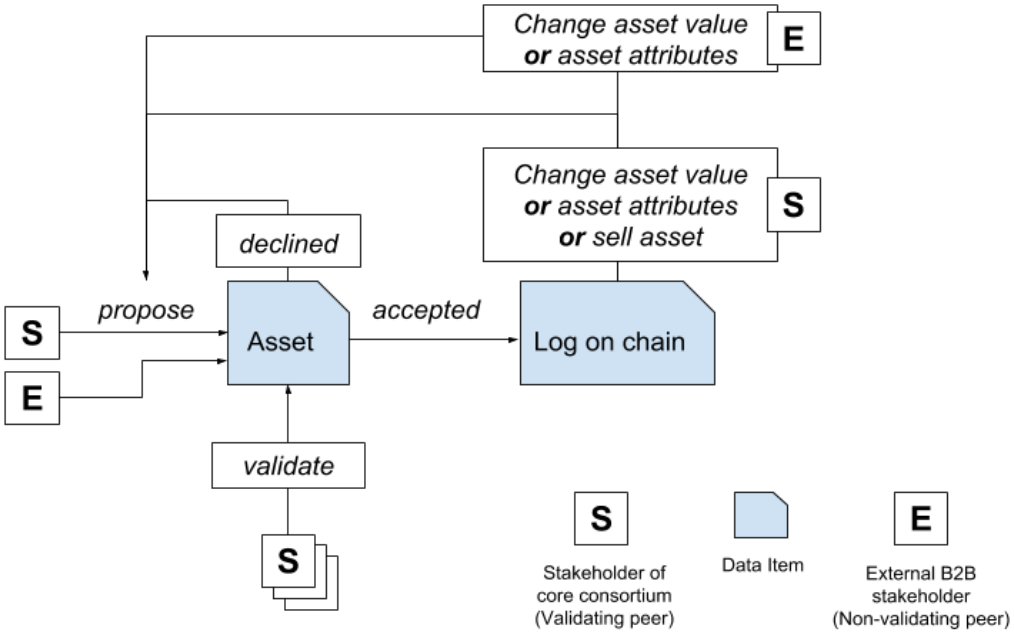


Figure 27. B2B asset management process flow

Figure 28 visualizes how this process could look like in reality. A painting service company is hired by one or multiple members of the core consortium. This company proposes the technical and financial specifications related to its service. If the painting service is just hired by one member of the core consortium, to maintain their assets, this member has the exclusive validation right. If the painting service is hired in agreement with multiple core consortium members, the validation right gets distributed between them. Once an asset is accepted, there are two options: first, one or multiple members of the core consortium pay the painting service in a classical way and take over the shares created through this service. Second option is to offer the external stakeholder a lease contract, which ensures a constant revenue stream without taking risks in constructing, operating and maintaining the building (see chapter "*Lease model*"). Also, in the latter case, one or multiple members of the core consortium take over the shares created by the painting service.

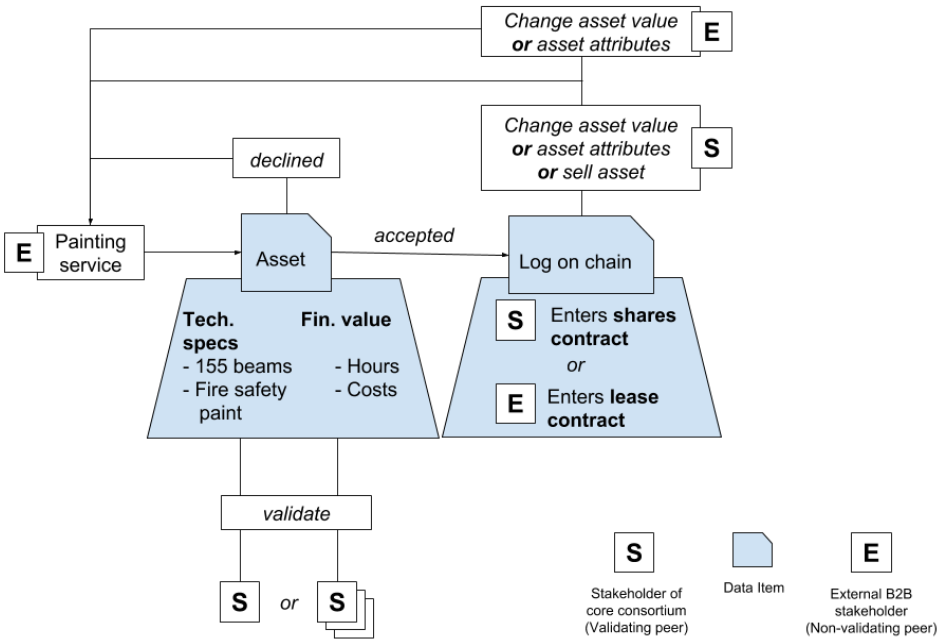


Figure 28. Illustrated example of B2B asset management process flow

On the blockchain (Figure 29), this means that transactions can be proposed by external stakeholders too. Once a transaction is validated and confirmed by the core consortium, the financial information is just accessible to the core consortium. This separation of information can be achieved by privacy-preserving techniques in blockchain which are one of the major challenges in the blockchain research and been heavily emphasised by researchers. The current solutions include private channels in HF, RingCT in Monero, and ZK-SNARKS in Zcash. We believe that, in the near future, there will be more advanced techniques that support privacy-preserving possibilities (Binh Nguyen, 2017; Hyperledger, 2017a; Marckx, 2017). Basically, channels are separate ledgers which allow confidential transactions between parties. In this case, a separation between operational and financial data is desirable. Beyond that, it is favourable to add a smart contract layer before it comes to a transaction. This can lower the effort to manually vote for every single transaction that is proposed. Instead, certain budgets and quantities can be predefined and executed automatically.

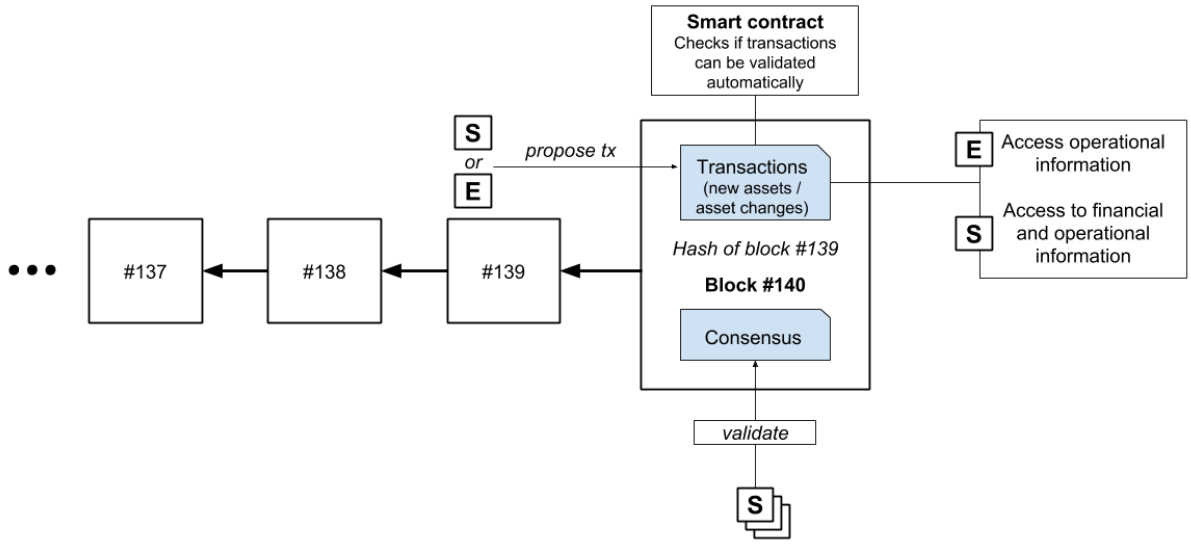


Figure 29. B2B asset management flow on the blockchain

Considering the step from the first to the second model, it is important to get external stakeholders on board. Like mentioned by Olaf Blaauw in the interviews; manufacturers, suppliers and subcontractors are crucial to collect data from the very beginning of the building process, but they have little interest and incentives to commit themselves to the 'bigger picture' of the building process – they usually care just for their own contribution. Thus, there has to be an incentive-system for such stakeholders that are just temporally involved in the project to take the extra effort to register their work to the network.

3rd model

The third model (Figure 30) adds a new group of stakeholders to the blockchain network; public consumers and investors. Consumers who simply want to pay their parking fees are eligible to do so with a "ParkingCoin". Since this model is estimated for around 2025, it is assumed that digital currencies will be mainstream until then. Further principles about the "Shares as tokens" are outlined later in this chapter.
The other group are public stakeholders who are potential investors. They get the chance to acquire shares that are liquidated by one or multiple stakeholders from the core consortium.

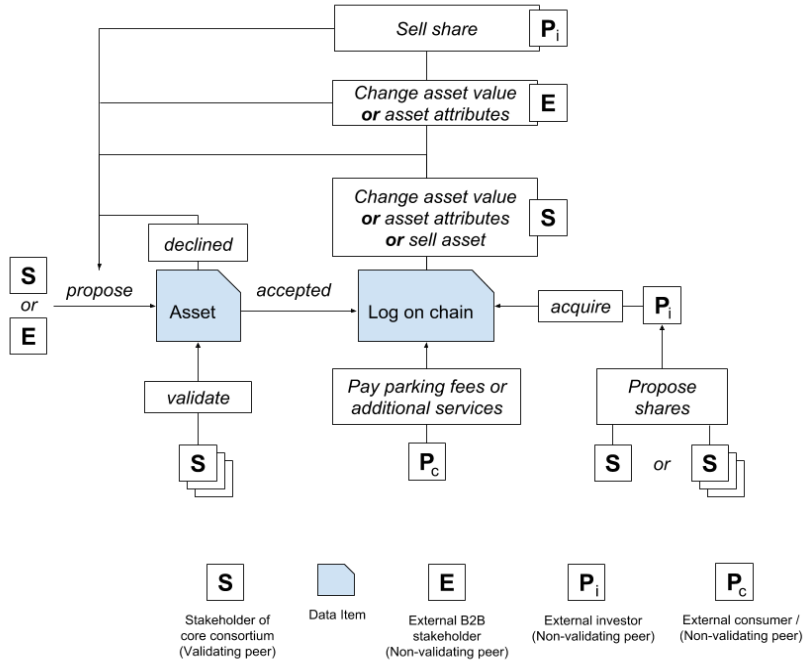


Figure 30. B2C asset management process flow

The newly proposed process is exemplified in Figure 31. The revenues collected by parking fees are directly distributed to the core consortium or private investors, according to the share that they hold. For public investors 10% of shares are offered by the core consortium. When the public investor accept this offer, they enable an equivalent revenues stream from the X-Decks projects. In case the share shall be sold, this has to be proposed to the core consortium.

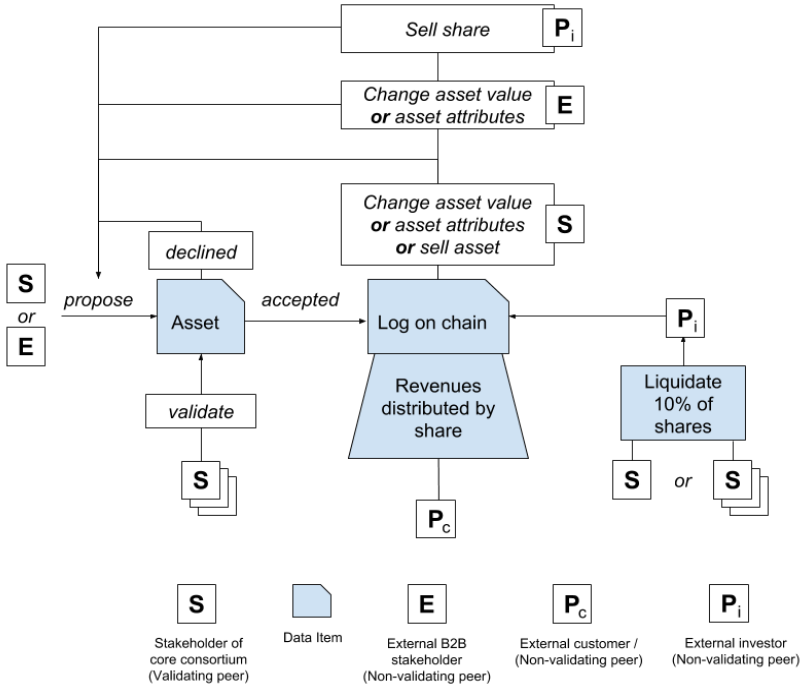


Figure 31. Illustrated example of B2C asset management process flow

The introduction of public parties comes along with a further increase of nodes in the blockchain network (Figure 32). The channels mentioned in the second blockchain model (Figure 29) get

expanded with a permissioned public channel. This channel ensures that customers have an easy and transparent access to “Parking coins”.
For external investors a further permissioned private channel is sufficient. Since they do not want to publicly reveal share holds.

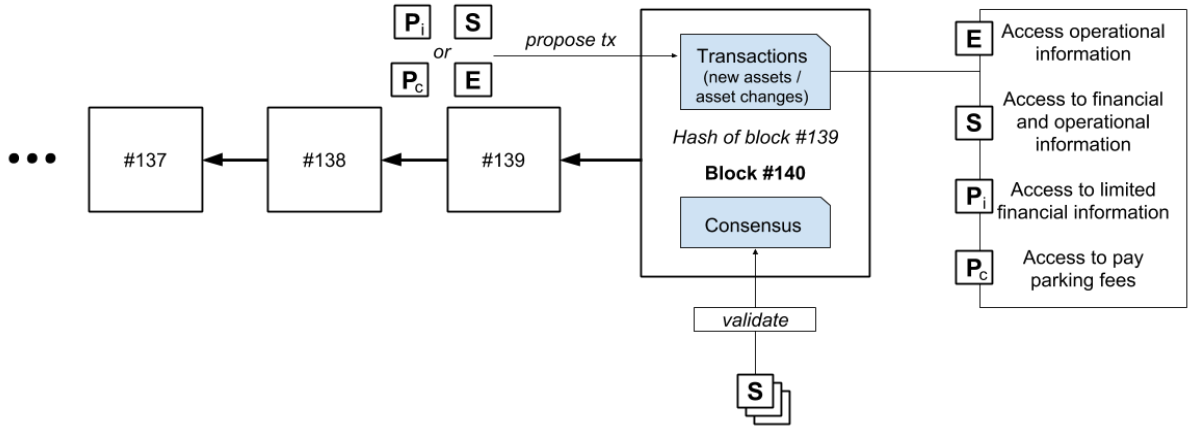


Figure 32. B2C asset management flow on the blockchain

The third model shall use the full potential of blockchain technology. Since multi-channel blockchains are so far just used as prototypes, there are no best use cases. This is why it still needs a couple of years to get such a network ready for production purposes. Also, a hybrid of public and private ledgers does not exist yet, but would fulfil the requirements for the X-Decks case to a high level. With RSK and Hyperledger Fabric, there are two promising initiatives that are working on the proposed solutions.

Conclusion

Looking back at all three models, it can be seen that these evolve around the business logic of the core consortium but with a steadily growing dependence and involvement of the stakeholders around them. The distribution of work, risks and revenues is here at the core of the model. This process of decentralization shall create capacity through linking many small companies to a trusted system, like mentioned by Teun van Schijndel in the interview with TBI. Increased transparency compared to the current situation shall help to create a closer cooperation between the parties. Furthermore, this system shall help to collect operational and financial data from the very beginning of the building process to make better predictions in later stages of the buildings’ lifecycle.

The asset management processes shall be tailored to the needs of the costumers and stakeholders. Therefore, it is important to slowly scale up the system and allow time for changes, where necessary. This helps to create a routine workflow once the prototyping stage is over. Finally, the new system shall help to accelerate the process of operating parking buildings and become a competitive advantages in the parking business.

This framework, a rather generic model, can be used as a blueprint for cases beyond X-Decks and the building industry, with small alterations. It shall be an inspiration, how supply chains and asset management can be stimulated in the future.

Shares as tokens

In the blockchain enabled asset management framework, shares can be refined with implementing tokens as the mean to simplify tradability. In cooperation with Zhijie Ren, the following ideas are formulated.

Instead of defining e.g. 20% of shares, simply 20% of the tokens are assigned and defining tokens has the same functionality as getting a share of profit in the system. This has two advantages; first, it is much easier for shareholders to sell or trade their shares in the market. Second, if new participants want to join the system, instead of rearranging the shares, new tokens are added.

There are different scenarios that can be can be drawn up using tokens in the case of X-Decks:

Scenario 1:
Company A, B, C ,D, E would like to build a X-Decks project. They create 10,000 tokens for this system. Each of them has 2,000 tokens and they agree on each one representing the usage of a parking slot and/or the right to collect money from leasing it. That is to say, there is a pool of all incomes from the parking, and each token represents a share of it.

Scenario 2:
Any stakeholder can sell part of their tokens to someone else. The token value increases as the construction goes on and more people want to buy it, even individual investors can buy a fraction of it.

Scenario 3:
A new player F wants to join, who provides an IT solution for charging the parking places and adds value to the parking. All stakeholders decide to give him 2,000 new tokens, since they think even if their shares decrease, their eventual income will increase — then the tokens are no longer representing a particular parking slot, but a fraction of profits from the pool. Now, the tokens have two benefits: either sell it to someone or use it to get a share of the profit.

Scenario 4:
When the project goes into operation, there are two possibilities: either pay the parking fee or buy a token for an hour and sell it. Company F decides to simply sell their tokens for parking. If you buy a token, you can park forever. If you buy half, it can be used for 20 years. A little fraction, e.g. 0.000001, is used to park for one hour. Therefore, a token becomes a currency for parking, in this case.

Scenario 5:
Another parking company would like to join the system and accept this token. Then, since it also adds value to the system, the company could also get some new tokens. Eventually, this token becomes a currency for parking in general.

Answering fifth and main research questions.

Considering that the fifth research question takes into account different user attitudes of the asset management framework, the main research question is answered first, since the creation of the framework comes chronologically first.

Main research question:

> *How can asset management in the supply chain of the X-Decks case be applied to a blockchain enabled asset management framework?*

Asset management was carved out to be the best entry point to show the potential of blockchain technology in the supply chain of the X-Decks case. Assets require multiple middlemen to be registered, validated and traded in the building industry.
The blockchain enabled asset management framework shows how processes can be tackled with a new organizational approach:

As outlined in the three models of the asset management framework, it starts as a registration and trading platform between the core consortium. Assets that are traded on the network include land, working hours or construction materials. The financial and technical specifications of these assets are proposed, validated and added to the blockchain. Possibly, first managerial data can be derived from the technical and financial specifications to optimize the coordination of the supply chain during the construction phase. In this stage, the network is equal to a distributed database but unfolds its potential with the following layers.
In the second model, the network is scaled up and enables B2B stakeholders to join the network. There are three opportunities for these stakeholders' commitments; getting paid one-off, entering a lease contract or acquiring shares and becoming part of the core consortium. Theoretically, this model enables the entire B2B environment of the X-Decks project to join the network. This shall make a seamless documentation and operation of the X-Decks project possible in a new collaborative and transparent way. The permissioned private blockchain network also allows transactions on "channels" which are confidential transactions on separate blockchains. These are necessary for the core consortium to keep especially their financial data scarce.
The third model extend the blockchain network with a permissioned public layer. Here, the transition from a B2B to a B2C network is intended with costumers paying the parking fees digitally with a parking coin and the possibility for the core consortium to liquidate parts of their shares to public investors.

Fifth research question:

> *How can different stakeholder attitudes affect the framework?*

Figure 33 describes several factors that can influence the stakeholders' attitude towards the framework. The direction of the arrows describes an increase of the particular factor between the different layers of the network.

Important factors of the blockchain enabled asset management framework are to distribute risks, liabilities and revenues among the shareholders to create capacity

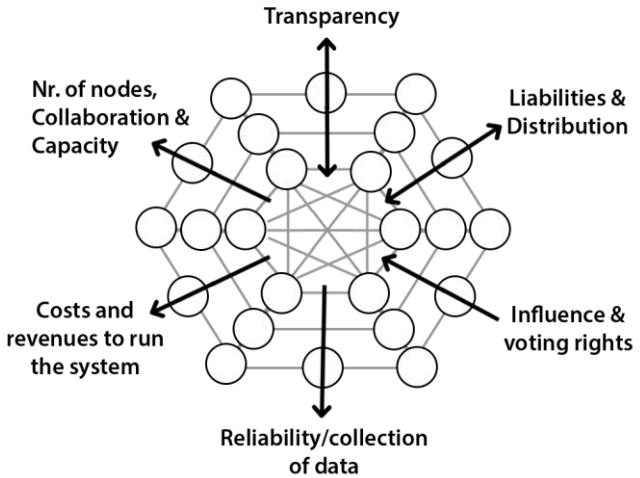


Figure 33. Factors influencing the user attitudes

and make middlemen like developers and partly contractors obsolete. This can just become true when enough parties actively participate and distribute competences and risks on the network (see Figure 33 “Liabilities and Distribution” and “Nr of nodes, Collaboration & Capacity”).

The factor “Transparency” can increase in both directions. The core consortium exchanges data transparently between each other and can make single confidential deals among each other as specified in the description for Figure 29. Considering transparency towards the outer layers, it depends on the core consortium how much transparency it will allow towards the B2B stakeholders and the public layer.

Further, “reliability/collection of data” will depend on the willingness of the core consortium and B2B stakeholders to contribute and maintain the system. Also the user interface and user experience is crucial to document the “right” data and to make the user interaction as efficient as possible.

During the interviews, most parties were, in first instance, reluctant to take over shares. It is none of their core competences to estimate development risks or operate a building. Therefore, the adaption of leasing contracts could be an alternative to connect stakeholders to the network. This is also important to establish parking as a service and a recurrent business model. If stakeholders reject to enter lease contracts and want to be paid one-off, this can be absorbed by a core consortium with enough capacity.
There are drawn up three scenarios to describe different stakeholder attitudes in the different layers of Figure 33:

- First, building up a core consortium as described in the 1st Model, which can pay off external B2B stakeholders that do not want to enter lease contracts.
- Second, if there are just a few and/or small parties in the core consortium with little capacity, the external B2B stakeholders could create capacity with entering leasing contracts and providing “reliable data”(Figure 33). Of course, the risk of paying off the lease contracts remains still with the core consortium but then there are no high upfront payments that have to be made by the core consortium.
- A third but rather unrealistic scenario is to liquidate a high percentage of shares to individual, public investors and indirectly outsource risk to them. This is just possible in the third scenario. The factor “Influence&voting rights” in Figure 33 describes this since the core consortium holds all rights to manage and distribute information on the blockchain.

The best case is, of course, when both, the core consortium and the external B2B stakeholders, contribute to steady growth and commitment to the system.

Blockchain prototype

The following chapter shows how the 1st Model from the chapter “Blockchain enabled asset management framework” can be turned into a first working prototype with the help of Hyperledger Composer (Linux Foundation, 2018).

The literature review identified the Hyperledger project as the most suitable blockchain platform for X-Decks at this moment. As a platform for permissioned private blockchains it offers the right environment for a core consortium of trusted parties to familiarize with blockchain technology. This chapter shall help to show how the business logic of the X-Decks project can be implemented.

The three cornerstones that have to be defined are **Participants, Assets and Transactions**. This means, for Model 1 (Figure 34), that Participants are the members of the core consortium, Assets are anything that a member wants to register and validate on a blockchain as a digital twin and transactions are: 1st to propose an asset; 2nd to validate an asset; 3rd to accept or reject an asset and 4th to change value, attributes or ownership of the asset.

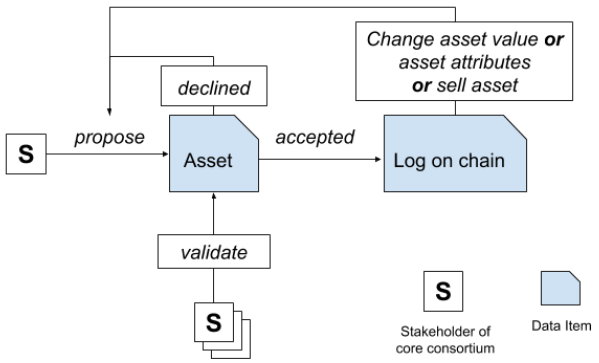


Figure 34. 1st Model

Test it yourself!
This business logic was implemented in the file structure, typical for a Hyperledger Composer project, shown in Figure 35. More details and the content of each file can be pulled from the github account (https://github.com/3en3en/xdecks-network). In the repository, the “./dist/*xdecks-network.bna”* file can be used to run the prototype online in the Hyperledger Composer Playground (http://composer-playground.mybluemix.net/). Click on “Deploy a new business network”, then choose “Drop here to upload and or browse”, upload the “*xdecks-network.bna”* file and click “Deploy” on the right side. Then, click “Connect now” and you run the prototype already!
On top, in the “Define” tab, you can browse the Model File, Script File and Access Control like shown in Figure 35. A detailed explanation of the code will not be given here but, in principle, the Model File defines the participants, assets, transactions and attributes that can be given to these. The Script File connects with the transactions from the Model File and defines the backend. The “Smart Contracts” are also defined here. The Access Control, as the names says it gives create, update, delete and read rights for the participants on the network. A Query file is not defined.

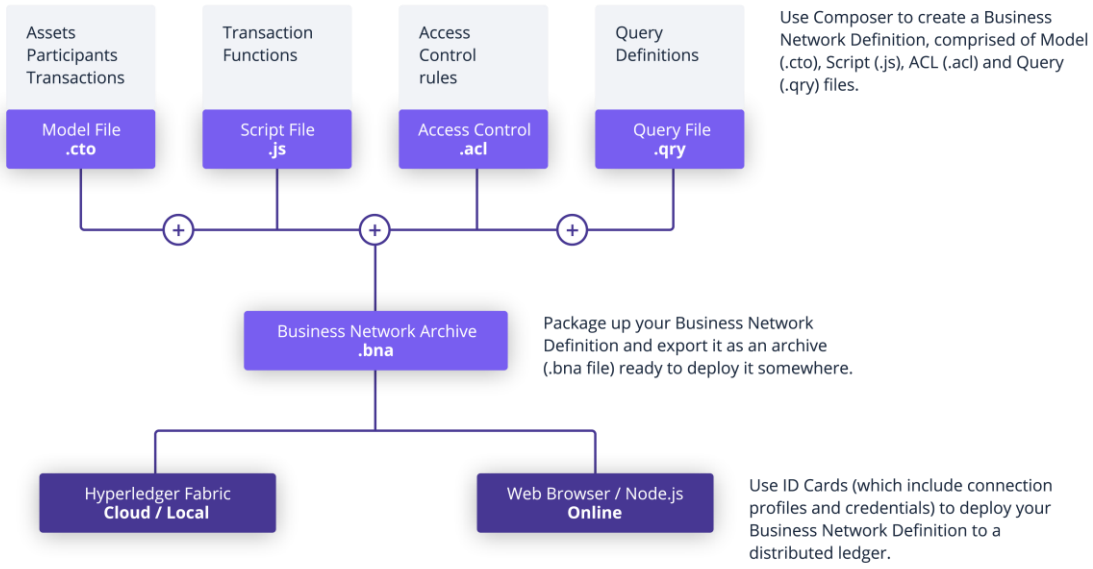


Figure 35. Business Network Overview (Foundation, 2018)

Further in the Composer Playground; on top of the page, click the tab “Test” to interact with the business logic. On the left side, under “Participants”, “Member_CC” (for member core consortium) can be chosen and on the top right a “New Participant” can be created. Just fill in a name of an organization e.g. ("organization": "Municipality_Utrecht") and click “Create New”. Create another or more “Member_CC” to populate the network, then switch to “XdecksAsset ” on the left side. “Create New Asset” and fill in for example:

```
{
  "$class": "org.xdecks.XdecksAsset",
  "assetName": "Land",
  "member": "resource:org.xdecks.Member_CC#Municipality_Utrecht",
  "state": "TO_BE_VALIDATED",
  "minVotes": "2",
  "votes": 0,
  "value": "700000Eur",
  "description": "7000sqm in Utrecht"
}
```

and “Create New”. Here the “Member_CC#Municipality_Utrecht” proposes (“TO_BE_VALIDATED”) the asset “Land”. Minimum two votes from other members are necessary to validate the asset and 0 votes is the starting position. The proposed value of the land is 700.000 Euro.

Now that the asset is proposed, continue with “Submit Transaction” on the left side. Choose “Validate” in the drop-down menu. Fill in one of the other participants that you created and e.g. the asset “Land”. When clicking “Submit”, you validated the land with the according participant. You can see under “XdecksAssets” in the Data column that 0 changed to 1 under “votes”. You can give another vote with another participant to fulfil the minimum 2 votes.

Once the asset received two votes, go to “Submit Transaction” and choose “ChangeValidationStatus”. Fill in member and asset, then fill in “ACCEPTED” at “newState”. Then, “Submit” and check how the state has changed under “XdecksAssets” in the Data column. Congratulations! The asset is now validated and logged on the blockchain. Click on “All Transactions” on the left side and follow along the records on the blockchain. Since every transaction requires a member authentication, it can be easily checked here who submitted what in case something went wrong.

As a last step, click on “Submit Transaction” and choose “ChangeAssetValue”. Here, you can change the value of any asset. After the value is changed, you can review the new value when you click on “XdecksAssets” in the Data column. While still in the “XdecksAssets” tab, do not forget to change the “state” back to “TO_BE_VALIDATED” and “votes” back to 0 by clicking on the little pen symbol in the top right.

This short tutorial should have taken you through all the steps required in the 1st Model (Figure 34). However, be aware that the prototype is created for illustrative proposes only. The participants’ rights are not implemented yet and votes, values, etc. can be easily manipulated as an “admin”, but it is still possible to trace changes back under “All Transactions”. In that sense, manipulation and the responsible party can be detected easily.

Local version

As shown in Figure 35, the prototype can be also ran locally, besides using the Hyperledger Composer Playground online. Follow the instructions here (https://hyperledger.github.io/composer/latest/tutorials/developer-tutorial) in combination with the github repository (https://github.com/3en3en/xdecks-network) to install a local version of the xdecks-network. The following screenshots show the easier accessible user interface of the local version:

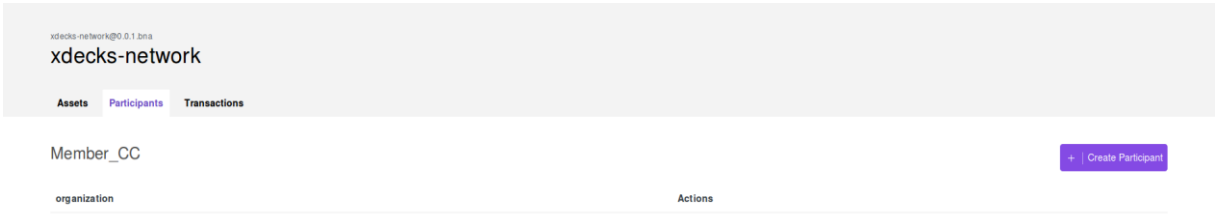


Figure 36. Screenshot xdecks-network empty participant registry

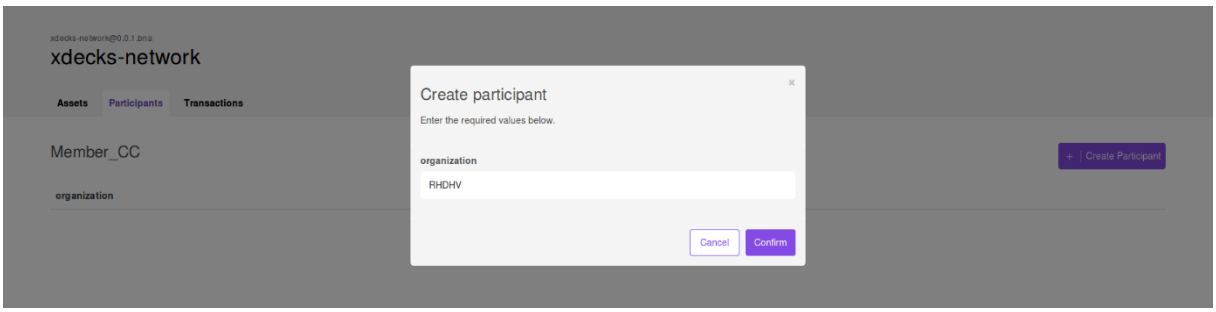


Figure 37. Screenshot xdecks-network “Create Participant”

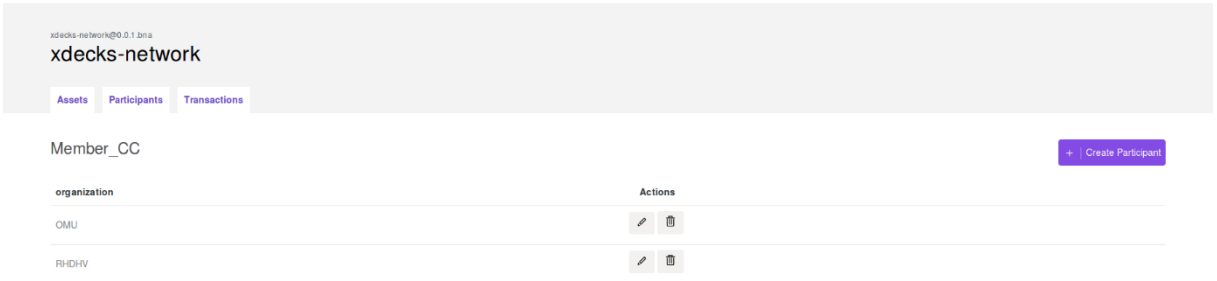


Figure 38. Screenshot xdecks-network participant registry with two members

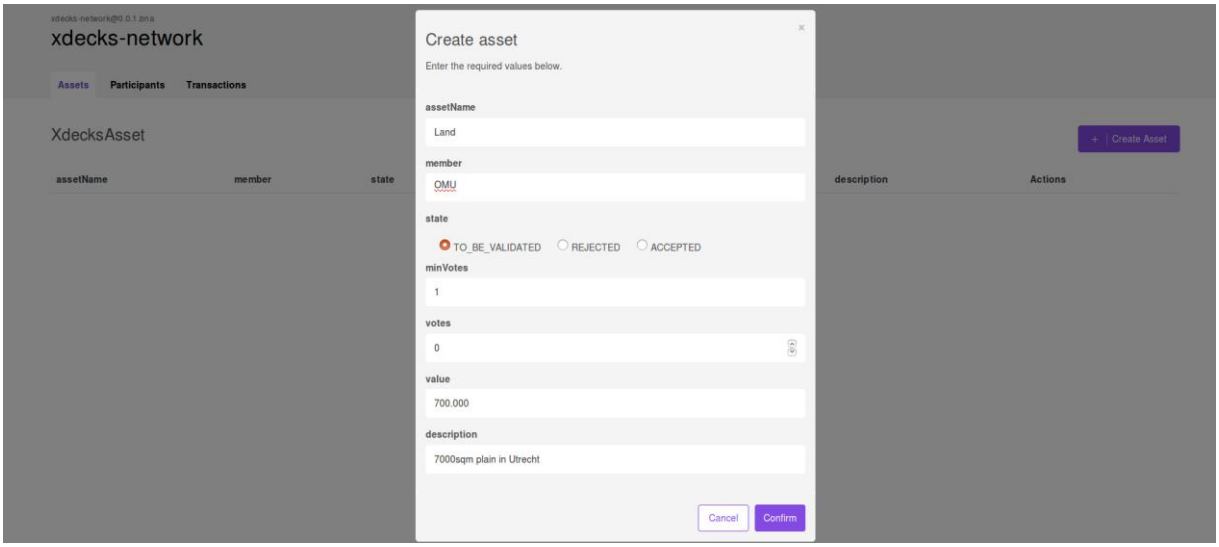


Figure 39. Screenshot xdecks-network "Create Asset"

Figure 40. Screenshot xdecks-network asset registry with one asset

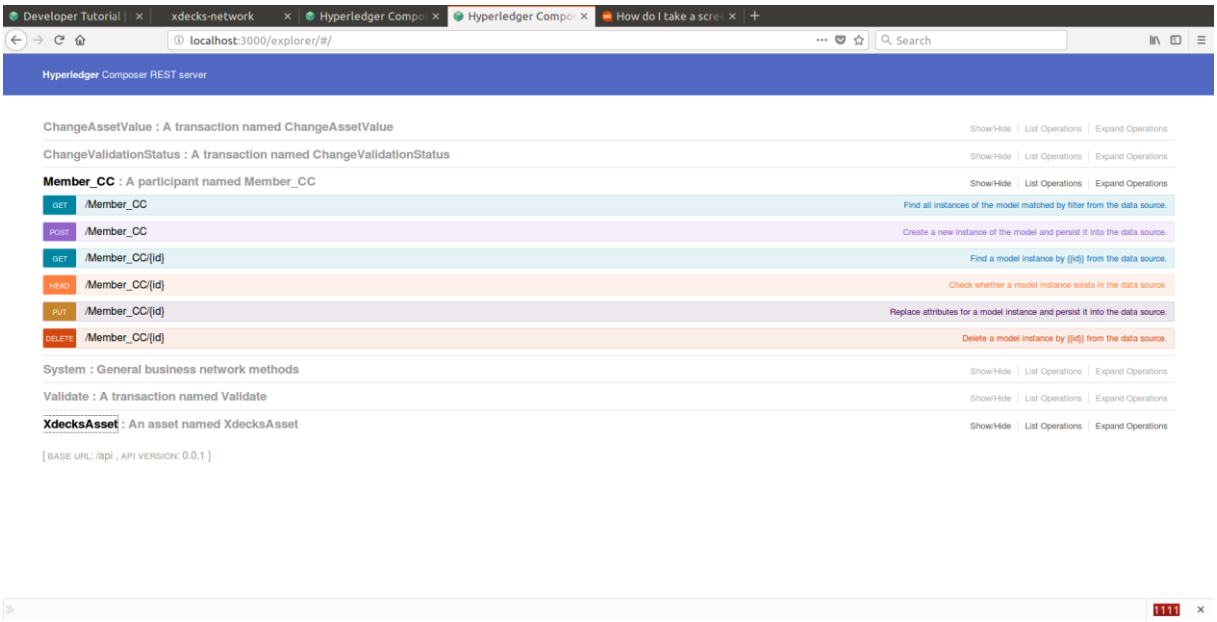


Figure 41. API interface

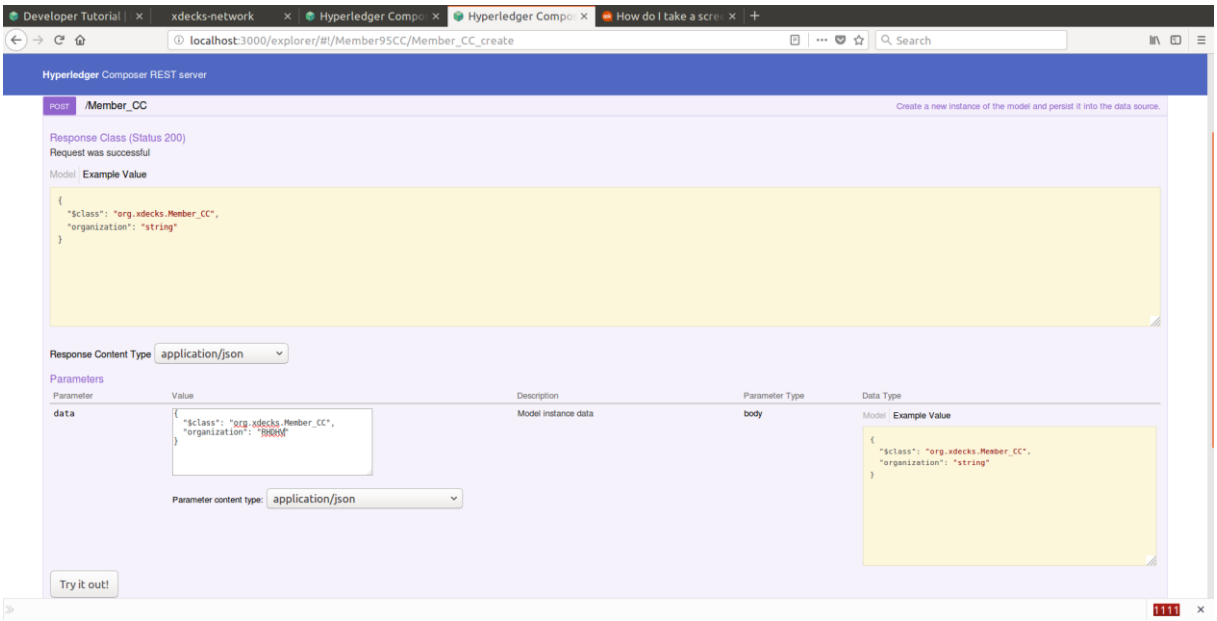


Figure 42. API Member_CC POST interface.

The processes shown in the screenshots above should be easily recognized if you followed the Hyperledger Composer Playground instructions above. The “Transactions” tab was unfortunately not working in this version yet.

Conclusions

The prototype shall help to concretise the asset management framework and show the current state of a blockchain platform. In principle, a blockchain prototype has to go through two stages: standardization phase and testing phase. First the transactions, smart contracts and interoperability

with existing ‘Engineering information management systems’ (EIMS) and ‘Enterprise resource management systems’ (ERMS) of the core consortium has to be coordinated. Existing best practices can be taken over or linked to the processes on the blockchain interfaces of the X-Decks project. The collected data can then be used to launch tender processes, sending payment requests, documentation archiving, controlling model accesses, updating transaction settlements, asset evaluation, predictive maintenance etc. There are several fields beyond resource base management like supply chain management, knowledge management, project management and human resource management that can be tackled with the collected data. (Winch, 2010)

In terms of scalability, it can be said “larger blocks mean larger storage space and slower propagation in the network. This will gradually lead to centralization as less users would like to maintain such a large blockchain. Therefore the trade-off between block size and security has been a tough challenge” (Platt, 2017; Zheng et al., 2017). This means, for the prototype, that extensive documentation and large files should be avoided among a vast amount of nodes. Within the network of the core consortium it might stay manageable with appropriate computational power. The larger the network grows, the smaller the transaction data is a thumb rule.

Decentralization is not really taking place in this prototype yet, since all participants are created and controlled from one admin user. In the next steps more nodes should be added to test the blockchain network in a more distributed environment. Furthermore, a certification is necessary to control the user registration process. Also, an adequate solution for public and private key management is not implemented in the prototype yet.
The Hyperledger framework provides a suitable blockchain environment for the core consortium and the B2B environment, but when X-Decks shall be made available to public parties, it has to be linked to another blockchain platform, like e.g. Ethereum.
Generally, the Hyperledger project provides a good documentation and is maintained by an active community that is also working on keeping the entrance barrier low. The create the prototype the “Blockchain for Business” online course on edx.org gave good introduction. IBM also started to commercialize the project by providing a blockchain as a service product.

Closing Chapters

Conclusions

The X-Decks case does not unfold its full potential on first sight. Established real estate knowledge with time perspectives of 20-50years does not apply here. Consequently, long-term investment risks can be reduced to a minimum by scaling down the structure with lowering demand and reusing it in at other locations in a circular way. This flexibility opens new business opportunities that were confirmed during the interviews e.g. new urban developments need transfer solutions because the long-term vision of policy makers is to reduce parking spaces. In order to incorporate the existing structural solutions of X-Decks into a supportive organizational process, this research chose blockchain technology as a mean.

Blockchain combines peer-to-peer networks with public-key cryptography, timestamping of transactions and a distributed consensus that was not done in this way before. The technology is in an early stage of development and exploitation and needs to go through an inter-industry standardization process to really unfold its potential. At its core, blockchain provides decentralization of processes and this can lead to an increase in efficiency, trust, transparency, security and immutability.
The interviews show that there is consensus about the need to increase cooperation and transparency between stakeholders to reduce risks during the construction and operation processes. This confirms the hypothesis of the problem statement that organizational silos hinder cooperation in the building industry.
In the further analysis of the interviews it became clear that more transparency and cooperation need to be balanced with the need to preserve organizational silos to some extent, since they are crucial to run a business model based on scarce information or materials.

“Whereas the utopian view has argued that blockchain technology will affect every market by removing the need for intermediaries, we argue that it is more likely to change the nature of intermediation”(Catalini & S. Gans, 2016)

In this respect, the asset management framework starts on a permissioned private blockchain to preserve confidentiality. It offers a platform to trade assets and distribute revenues and liabilities within a core consortium. This distribution shall help to build up capacity to compete with currently established market parties whose role is to act as a middleman and to provide capacity as one party. In further steps, the framework can be scaled up to include B2B stakeholders outside of the core consortium with reduced liabilities compared to the core consortium. The aim is here to create a denser web of data to better predict and coordinate the construction and operation of X-Decks projects. The concept of acquiring shares for the core consortium and leasing for the B2B stakeholders are crucial to make the project flourish.
In the last step, the network can be further increased in the number of nodes and business complexity with a permissioned public blockchain. This step would utilize the full potential of blockchain technology and offer public customer access to pay their parking fees with a parking coin and individual investors to acquire shares from the core consortium.

These three steps shall show how blockchain can be used as a general-purpose technology that avoids creation of “islands of automatization”.

The creation of a blockchain enabled asset management framework is one of many ways to enhance cooperation and transparency. Therefore, it was important to make good judgement between expectations, real needs and technological possibilities and limitations.

The X-Decks project is a rather simple building typology and can be run more efficiently with good bookkeeping, even analogous. But the scope of this research was from the very beginning to use the X-Decks case as a thought experiment to touch upon inter-industry moving topics like digital transformation and business innovation. This is why the means to establish a blockchain network might seem too high to meet the expectations and needs of the stakeholders in the X-Decks project. But, when taking into account that these efforts can result into new insights and competitive advantages for whole business segments in the built environment, then it might be well worth the efforts. Furthermore, using the X-Decks case as a blockchain pilot can add value by establishing valuable partnerships with other innovative stakeholders and position RHDHV as a pioneer in the field of digitalization in the built environment, where businesses are rather reluctant and late adopter of new technologies. Furthermore, the interviews started a dialog to inform and establish cooperation with external stakeholders that can be further strengthened in the future. In that sense, the research is not just about technological implementation but also a starting point to bring the built environment one step further in the digital age.
At last, the framework shall help to create a recurring business model and X-Decks is here an eligible solution to extend the service palette of RHDHV over the whole lifecycle of a building project. By now, it is not happening to collect data as early as in the planning and construction phase and use this data consistently for financial, managerial and operational tasks in later phases of the building lifecycle.

Research limitations

Timely screenshot
The X-Decks project is ongoing work for RHDHV and negotiations with potential stakeholders and clients changed over the course of this thesis. Thus, all data collected from the interviews and proceeded in the further chapter represent the status of the X-Decks project until the beginning of 2018.
Furthermore, this thesis research takes as a basis that the demand and the associated market research for parking spaces in the Netherlands is previously conducted and determined by RHDHV.

Expertise
As a student of management in the built environment, I am neither an expert of distributed computing nor a cryptographer. For this reason, I could not grasp every concept of blockchain technology down to its basis. Throughout the course of this thesis, my interest and knowledge about the associated topics of computer science grew but this was mainly done with self-studies.

Interview feedback
A general reluctance of the share model during the interviews showed that the scenarios were still too preliminary and it was too early to judge the concept, since the asset management framework and prototype where not yet available. When looking at the stakeholders' need for transparency and risk reduction in the building process in well worth to involve the stakeholders again and present them the current state of research.

Blockchain focus
This research is highly focused on blockchain technology, alternative technologies are illustrated in the chapter "Related technologies". This is why it is important to keep in mind that there are different approaches besides blockchain technology to accomplish the same or similar results. An

appropriate question for further research would be: to which extend could the asset management framework be accomplished without blockchain technology?

Research plan

The research plan (see “Appendix 7 – Research plan”) outlines the main tasks, milestones and interdependencies of the tasks in this thesis research.

Further research

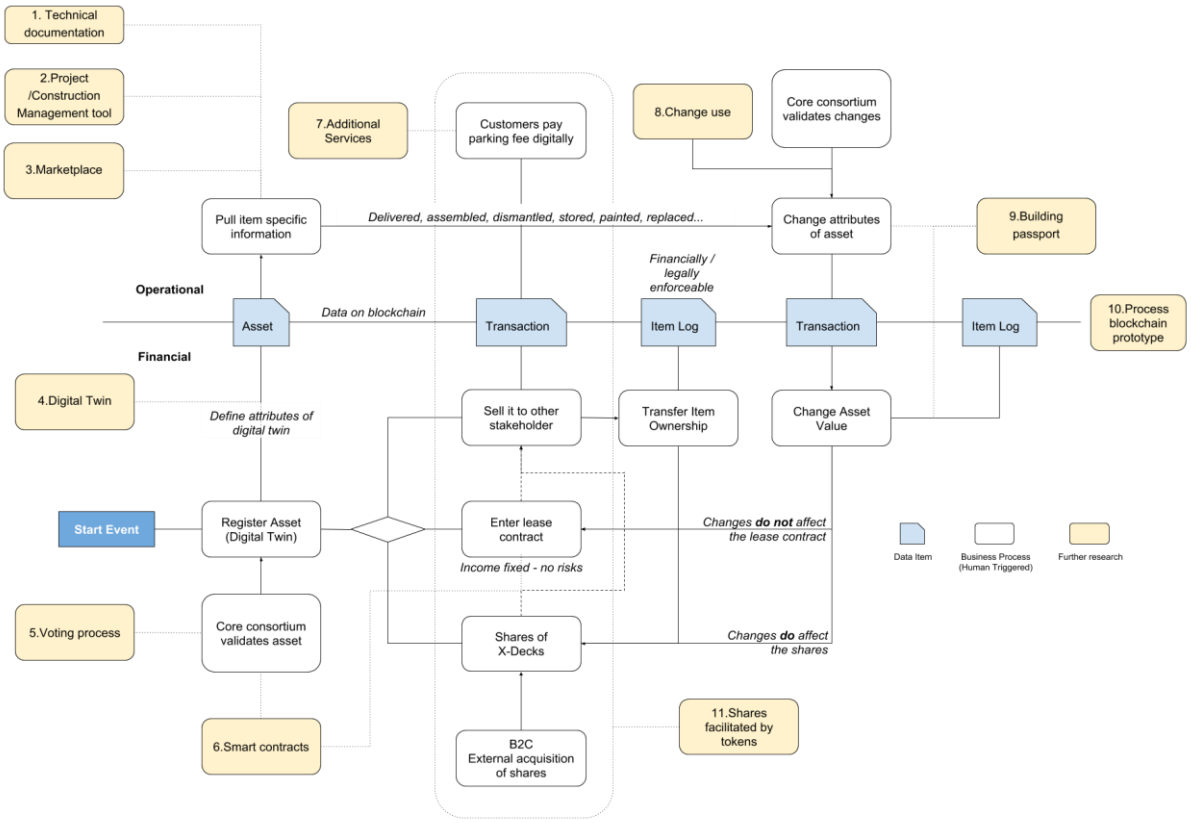


Figure 43. Links to further research in the asset management framework

Overlaps digital twin & building passport…opportunities!

This research offers multiple opportunities for further research. Figure 43 shows a merged version of the 3rd asset management model with possible links to further research (yellow boxes). The numerical order is no ranking in terms of priority or ease of implementation but shall just help to orientate through Figure 43.

1. Technical documentation
The assets on a blockchain need to be backed by technical documents. In which depth is it useful to process and link data from Building Information Models to a blockchain or an external database?

2. Project and Construction management tool & 4. Digital Twin
How to use the technical and financial information on the blockchain to improve the coordination and management of a construction site? The creation and management of a digital twin plays here a key role, especially research to decrease the gap of a physical and digital asset through IoT devices and possibly Artificial Intelligence. As long as there is a double effort necessary to maintain and update a Digital Twin, chances for mistakes and efforts are high. Just when IoT devices and sensors can create a seamless updating process of the physical and digital sibling, full deployment is possible. The information saved to a Digital Twin can be used to create a live overview of the construction site and later of the building in operation. This is in direct benefit for the building passport (see No.9).

3. Marketplace
It is a rather extensive link. Here further research is necessary to create a platform to procure and tender external stakeholders for services at the X-Decks project. Information that is already available on the blockchain can be used to detail the procurement by tender.

5. Voting process
The consensus algorithm on the blockchain can become a complex undertaking. Shall all the members of the core consortium get an equal voting right or shall it be equal to their shares? Further, is there a minimum percentage of shares necessary to join the core consortium or to get a voting right? Further, can public parties and individuals participate in maintaining and validating the blockchain from the 3rd model on?

6. Smart contracts
They are still in an early development stage but are one of the most promising aspects of blockchain technology. Which exact data shall be included, in order to avoid repetitive voting work for the core consortium? To which extend are smart contracts already legally enforceable and what has to be backed up by paper-based contracts? Artificial Intelligence plays here an important role to recognize patterns in the system and help to automatize them. Further, how to better define the liabilities, responsibilities, guarantees of the different stakeholders ,that are freed up through replacing middlemen, in a smart contract? This research topic can be approached from both, a legal and technical, programming side.

7. Additional services
How can the business model of X-Decks be extended through additional services around the parking services and beyond it? Once the parking service is established further services can be added like a toilet, a kiosk or a little supermarket in highly frequented spots. Also, car charging and the use of the garage as an energy hub is imaginable. Furthermore, the X-Decks project can be integrated to existing services like parkbee or yellowbrick to offer a better costumer experience.

8. Change of use
How can the modular construction systems of X-Decks be advanced to facilitate further functions? Besides adding services like discussed in No.7, the supply chain established for the X-Decks project can be used to build slightly more complex typologies like a storage building or warehouses and, in a next step, more complex but still highly modular and standardized building typologies like e.g. supermarkets.

9. Building passport
How can the collected operational and financial data be used to make better predictions about the residual values, depreciation of the building value, maintenance state, etc? Performance testing can be done with this data and different options can be created to run a building at low costs, most comfortably or most sustainably. Possibly, these options can be linked to the marketplace and Digital Twin (see No.3&4) and to wallets on a blockchain that automate the payment process through smart contracts (Leyssens, 2018). Furthermore a link to governmental funds can be established to check which work can be subsidised.

10. Process blockchain prototype
The prototype from this thesis research can be further scaled up towards the 2nd or even 3rd model. Including more nodes, smart contracts and a more complex business logic.

11. Shares facilitated by tokens
How can a token be most efficiently tailored to the X-Decks project to add value to the system? Shall there be a fixed amount of tokens, like in Bitcoin, or can tokens be added like in Ethereum? The token economy is an increasingly complex and exciting economic and financial playground that is well worth further research.

Possibilities and resulting changes in the building process through blockchain technology

Considering the whole lifecycle of a building (Table 4), the implementation of blockchain technology has to be contemplable as early as in the feasibility study. Once stakeholders come together and commit e.g. working hours to a project, the possibility can be given to register and manage these commitments on the blockchain. It does not necessarily have to lead to a share model, like proposed in the case of X-Decks, but the blockchain can be used as a digital asset registry, building passport or contractual management platform throughout the lifecycle of a building. Complete documentation and mutual validation are here key components.

Feasibility study	Design / Pre-Construction	Construction-Execution	Commissioning/ Handover	Operations/Maintenance	Dissemble/ Re-use

Table 4. Phases of the building process

Similar as described in Figure 23 (Chapter “

Share model”) the data on the blockchain can be reused in the last stage “Dissemble/Re-use” (Table 4), when a few stakeholders stay owners of the materials at the end of the lifecycle and reuse these materials for a new project. This commitment over longer periods in the project can open up a new possibility to financially enhance circularity by collecting information and keeping parties involved over longer periods than current practice building projects. The in depth-financial and managerial framework that can be derived from the data on the blockchain is up for further research.

Another field of further research is the digital execution of key steps of a project, that are recorded and transmitted from the BIM Model to the Blockchain, enabling the achievement of various automated actions: launching tendering process, sending payment requests, documentation archiving, controlling model accesses, updating transaction settlements, and much more.

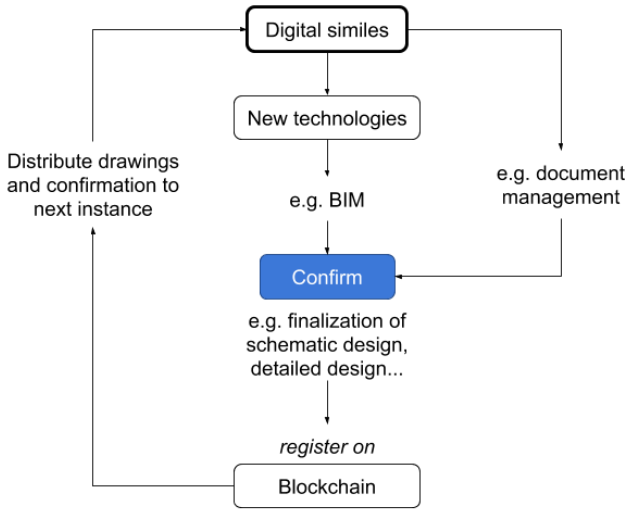


Figure 44. Digital similes

Figure 44 illustrates here one example. For the digital simile of e.g. drawing data in BIM, blockchain could be used to establish a confirmation process, when a certain state of the drawings is reached. This state can be confirmed by just one party, but also reviewed and confirmed by multiple parties to distribute liabilities. Once the confirmation took place the data gets encrypted and saved to the blockchain. Just one version of the data is used to continue the work and to trace back mistakes and liabilities, if necessary. Concerning BIM and blockchain it is also worth to take a look at (Turk & Klinc, 2017). At this point of time, this is among others interesting for companies like Autodesk that can expand their product palette through blockchain technology.

Further research about blockchain in the context of computerization in general

Current data management systems are vulnerable. Even institutions with high resources for digital security like CIA, NASA or banks are regularly hacked by individuals that breach sensitive data. Current digital infrastructure was scaled up too fast to catch up with security issues that are detected along the way. The fast-growing field of cyber security confirms that. Blockchain and related distributed ledger technologies promise to find a remedy, but they are still not scalable enough. Bitcoin proofs that, since 2009, nobody could breach its protocol. Certainly, there where breaches through exchange platforms or inappropriate storage of private keys that lead to losses, but this was due to interconnections to traditional, centralized systems. This is always a major difficulty for the adoption of new technologies; the transition process. While dealing with vulnerabilities of an old infrastructure the new one cannot fulfil its full potential.
There are three threats or also topics for further research about the future implementation of blockchain technology in the context of this research:

- Which level of decentralization is possible for institutions and companies?
- Scalability – the successive documentation and collection of data can lead to an unmanageable amount of data.
- On a mid to long term perspective quantum computing could make current principles of cryptography obsolete, one of the main pillars for blockchain technology.

It is hard to predict which consequences blockchain will really have for centralized institutions. Blockchain and distributed ledger technologies will be most probably used to strengthen their backend in terms of security and reliability of data and processing speed, but there are limits to decentralization for institutional and centralized companies. Sharing economy companies like Uber,

Airbnb or Deliveroo show how a core product can be outsourced, but the app administration is still centrally organized. Blockchain can bring these business models to the next level and replace the centralized app coordinator with a network of individuals that predefine terms and conditions through smart contracts and directly distribute revenues to the individuals.

Coming back to the X-Decks case; in principle an MS Excel sheet fulfils all requirements to manage assets between stakeholders in the X-Decks project, if everybody is honest and trustworthy. Since this not the case and the X-Decks network is supposed to work in an untrusted environment in the "3rd model" the spreadsheet is not really an advisable option – it is not capable to prevent fraudulent manipulation and run smart contracts.

Possibilities and resulting changes in the social organization

Considering the social aspects of implementing blockchain technology further in the X-Decks project, it is important to update the potential stakeholders with the blockchain enabled asset management framework and the prototype. The stakeholders interviewed in this thesis research and new ones that joined the process since the interviews were conducted can be involved. "Appendix 8 – Further research: re-involvement of stakeholders" shows one approach to again involve the stakeholders. The slides were used in a workshop at an early stage of the X-Decks project for first exploratory discussions between potential stakeholders. Especially the three tables in slide two and three can help to create a common ground of expectations, responsibilities and liabilities. These tables can be edited to further stimulate and define the blockchain related findings and possibilities for the stakeholders and the X-Decks project.

Considering the social and organizational aspect of blockchain technology in the built environment, blockchain can help to decentralize and strengthen the position of individual, smaller players. This is a chance and a threat at the same time: like seen in the token economy, individuals have all the means to run their own currency, which can weaken governmental and institutional influence and put the power in the hands of individuals. The same can be applied to the built environment; small companies or individuals can create a network of capacity. This can weaken bigger players in the sector, but these new networks still have to follow strict rules and laws in the buily environment, which result in physical assets. Consequently, it is not such a fundamental change as seen in the financial world that can be run 100% digitally. However, it offers a new option to financially implement circularity. Collecting information long term and possibly binding parties longer to a project compared to the current situation can benefit circularity by producing longer-lasting and reusable products within the X-Decks lifecycle.
When it comes to the implementation of coins and currencies that are run by cooperation's in the built environment, then the degree of disruptiveness increases. It can be seen as a crowdsourcing tool 2.0, as seen by many "Initial Coin Offerings", where barriers and regulations drop dramatically when an investment round is done with a specific propose coin or token.

Beyond the above mentioned aspects, Vitalik Buterin points out an interesting, more general social aspect about blockchain technology:

"Blockchain solves the problem of manipulation. When I speak about it in the West, people say they trust Google, Facebook, or their banks. But the rest of the world doesn't trust organizations and corporations that much — I mean Africa, India, the Eastern Europe, or Russia. It's not about the places where people are really rich. Blockchain's opportunities are the highest in the countries that haven't reached that level yet." (Buterin, 2016)

References

Ad van Driel, J. v. Z. (2016). *Strategisch inzet van vastgoed*. Amsterdam: WEKA Business Media BV.

Ahram, T., Sargolzaei, A., Sargolzaei, S., Daniels, J., & Amaba, B. (2017). *Blockchain technology innovations.* Paper presented at the 2017 IEEE Technology and Engineering Management Society Conference, TEMSCON 2017.

Androulaki, C. C., Angelo De Caro, Andreas Kind, Mike Osborne, Simon Schubert, Alessandro Sorniotti, Marko Vukolic (Producer). (2017). Cryptography and Protocols in Hyperledger Fabric. Retrieved from https://www.zurich.ibm.com/~cca/talks/20170106-blockchain-rwc.pdf

Arvind Narayanan, J. B., Edward Felten, Andrew Miller, Steven Goldfeder. (2016). *Bitcoin and Cryptocurrency Technologies*.

BimWorld (Producer). (2017). BIM and Blockchain. Retrieved from https://www.bim-world.de/bim-blockchains-part-1-basics-blockchain/

Binh Nguyen, C. C., Jason Yellick, Elli Androulaki, Baohua Yang, Angelo De Caro, Kostas Christidis, Marko Vukolic (Producer). (2017). Multichannel Consensus. Retrieved from https://docs.google.com/document/d/1eRNxxQ0P8yp4Wh__Vi6ddaN_vhN2RQHP-IruHNUwyhc/edit#heading=h.hml58k6zw29h

Brennan, W. L. (2016). *Blockchian The Trust Disrupter*. Retrieved from http://www.the-blockchain.com/docs/Credit-Suisse-Blockchain-Trust-Disrupter.pdf

Bryman, A. (2015). *Social Research Methods*. New York: Oxford University Press Inc.

Buterin, V. (2016). What is Blockchain Technology? .

Cardeira, H. (Producer). (2016). Smart contracts and possible applications to the construction industry. Retrieved from http://rscl.ro/wp-content/uploads/2016/06/06_Helder-Cardeira_red.pdf

Castor, A. (Producer). (2017). A (Short) Guide to Blockchain Consensus Protocols. Retrieved from https://www.coindesk.com/short-guide-blockchain-consensus-protocols/

Catalini, C., & S. Gans, J. (2016). *Some Simple Economics of the Blockchain*.

Chesbrough, H., & Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. *Industrial and Corporate Change, 11*(3), 529-555. doi:10.1093/icc/11.3.529

coin.dance. (2018). Statistics

digitech. (2017). Decentralization.

Dijkstra, M. (2017). *Blockchain: Towards disruption in the real estate sector.* (Master of Science), TU Delft.

EBA, W. G. (2016). *Applying cryptotechnologies to Trade Finance* Retrieved from https://www.abe-eba.eu/downloads/knowledge-and-research/EBA_May2016_eAPWG_Applying_cryptotechnologies_to_Trade_Finance.pdf

Echevarria, R. (Producer). (2017). 2017: A Summer of Consensus. Retrieved from https://software.intel.com/en-us/blogs/2017/10/05/2017-a-summer-of-consensus

El Maouchi, M. (2018). *DECOUPLES: A Privacy-Preserving Solution for Traceability in Supply Chains.* Delft University of Technology. Retrieved from https://repository.tudelft.nl/islandora/object/uuid%3Af5be8c53-4251-4c6a-922d-d67b125fcd75?collection=education

ENISA. (2017). Distributed Ledger Technology & Cybersecurity.

Evry. (2016). Blockchain: Powering the Internet of Value

Firica, O. (2017). Blockchain technology: Promises and realities of the year 2017. *Quality - Access to Success, 18*, 51-58.

Foundation, L. (Producer). (2018). Welcome to Hyperledger Composer. Retrieved from https://hyperledger.github.io/composer/latest/introduction/introduction.html

Friedlmaier, M., Tumasjan, A., & Welpe, I. (2016). *Disrupting Industries With Blockchain: The Industry, Venture Capital Funding, and Regional Distribution of Blockchain Ventures*.
Giancaspro, M. (2017). Is a 'smart contract' really a smart idea? Insights from a legal perspective. *Computer Law and Security Review*. doi:10.1016/j.clsr.2017.05.007
Goodwin, K. (2017). Byzantine Fault Tolerance in a Distributed System
Greenspan, G. (Producer). (2016). Beware of the Impossible Smart Contract. Retrieved from http://www.the-blockchain.com/2016/04/12/beware-of-the-impossible-smart-contract
Gupta, V. (2017). Programmable blockchains in context: Ethereum's future, by Vinay Gupta.
Haaker, T., Bouwman, H., Janssen, W., & de Reuver, M. (2017). Business model stress testing: A practical approach to test the robustness of a business model. *Futures, 89*(Supplement C), 14-25. doi:https://doi.org/10.1016/j.futures.2017.04.003
Hackett, R. (2016). LinkedIn Lost 167 Million Account Credentials in Data Breach.
Hassan, H. (2018). *From Data to value in real-estate investment management.* (Master of Science), TU Delft.
Hyperledger (Producer). (2017a). Channels. Retrieved from http://hyperledger-fabric.readthedocs.io/en/release-1.1/channels.html
Hyperledger. (2017b). Hyperledger Architecture, Volume 1.
Hyperledgerwiki. (2018). Use Case Inventory.
Iansiti Marco, K. R. L. (2017). The Truth About Blockchain. *Harvard Business Review*.
IBM (Producer). (2016). Making Blockchain Real for Business at the "z Systems Agile Enterprise Development Conference - 2016" Retrieved from https://www.slideshare.net/IBMDevOpsforEnterpriseSystems/making-blockchain-real-for-business-at-the-z-systems-agile-enterprise-development-conference-2016
ISO. (2018). ISO/TC 307
Kachmazov, G. (2017). How the Blockchain and Distributed Ledgers Will Transform the Real Estate Market.
Leyssens, K. (Producer). (2018). What we've built to win the worlds biggest blockchain hackathon of 2018! Retrieved from https://medium.com/wearetheledger/what-weve-built-to-win-the-worlds-biggest-blockchain-hackathon-of-2018-ea01decfd60c
Lifthrasir, R. (Producer). (2016). What Is Blockchain And How Does It Apply To Real Estate? Retrieved from https://www.realcomm.com/advisory/738/1/what-is-blockchain-and-how-does-it-apply-to-real-estate
Linux, F. (Producer). (2017). readthedocs. Retrieved from https://hyperledger-fabric.readthedocs.io/en/latest/blockchain.html
Linux Foundation, I. (Producer). (2018). Hyperledger Composer. Retrieved from https://hyperledger.github.io/composer/latest/
Mansfield-Devine, S. (2017). Beyond Bitcoin: using blockchain technology to provide assurance in the commercial world. *Computer Fraud & Security, 2017*(5), 14-18. doi:https://doi.org/10.1016/S1361-3723(17)30042-8
Marckx, T. (Producer). (2017). Hyperledger Fabric v1.0: Multi-Ledgers, Multi-Channels, and Node.js SDK. Retrieved from https://www.altoros.com/blog/hyperledger-fabric-v1-0-multi-ledgers-multi-channels-and-node-js-sdk/
Marshall, J. (Producer). (2017). Estonia prescribes blockchain for healthcare data security. Retrieved from http://pwc.blogs.com/health_matters/2017/03/estonia-prescribes-blockchain-for-healthcare-data-security.html
McDermott, J. (Producer). (2017). What you need to know about BIM and the Blockchain. Retrieved from http://www.bimplus.co.uk/management/what-you-nee7d-kno6w-ab5out-bim-and-blockchain/
McGoogan, C. (2017). Hackers steal 2.5 million PlayStation and Xbox players' details in major breach
Meunier, S. (Producer). (2016). Blockchain technology - a very special kind of Distributed Database. Retrieved from https://www.linkedin.com/pulse/blockchain-technology-very-special-kind-distributed-meunier/?trk=mp-reader-card

Morgan, J. P. (2018). Quorum.
Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*. Retrieved from http://nakamotoinstitute.org/bitcoin/
Netherlands, E. o. t. (Producer). (2015). Philips lightbulb lease. Retrieved from http://nlintheusa.com/philips-lightbulb-lease/
Ngo, D. (2016). IBREA Founders: Sleepy Real Estate Industry Wakes Up to Blockchain. Retrieved from http://www.ibtcrea.org/librarybackpage/2016/8/9/ibrea-founder-sleepy-real-estate-industry-wakes-up-to-blockchain
Nooteboom, B. (2003). Trust: Forms, Foundations, Functions, Failures and Figures. *Personnel Review, 32*(5), 665-667. doi:10.1108/00483480310488397
Palfreyman, J. (2016). Open Innovation, blockchain & hyperledger. Retrieved from https://www.ibm.com/blogs/insights-on-business/government/open-innovation-blockchain-hyperledger/
Park4All. (2018). Retrieved from http://www.park4all.com/
Patrick, D., Robert, V., Alexander, V., & Lodewijk, B. (2017). Barriers to innovation within large financial services firms: An in-depth study into disruptive and radical innovation projects at a bank. *European Journal of Innovation Management*. doi:10.1108/EJIM-03-2017-0028
Paul, M. S. (Producer). (2018). Hyperledger — Chapter 1 | Blockchain Foundation. Retrieved from https://medium.com/swlh/hyperledger-chapter-1-foundation-7ad5bd94d452
Platt, C. (Producer). (2017). Thoughts on the taxonomy of blockchains & distributed ledger technologies. Retrieved from https://medium.com/@colin_/thoughts-on-the-taxonomy-of-blockchains-distributed-ledger-technologies-ecad1c819e28
Popov, S. (Producer). (2017). The Tangle. Retrieved from https://iota.org/IOTA_Whitepaper.pdf
Püttgen, F., & Kaulartz, M. (2017). Insurance 4.0: The use of blockchain technology and of Smart Contracts in the Insurance Sector. *ERA Forum, 18*(2), 249-262. doi:10.1007/s12027-017-0479-y
RHDHV. (2017). *Circular Hubs / FlexDeck. Flexibele multifunctionele parkeerhub*. business presentation.
Roser, C. (2016). PDCA Circle.
Rückeshäuser, N., Brenig, C., & Müller, G. (2017). Blockchains als Grundlage digitaler Geschäftsmodelle. *Datenschutz und Datensicherheit - DuD, 41*(8), 492-496. doi:10.1007/s11623-017-0818-8
Schueffel, P. (Producer). (2018). 10 years Blockchain. The Race is on: Blockchain vs. Tangle vs. Hashgraph. Retrieved from http://fintechnews.sg/16989/blockchain/10-years-blockchain-the-race-is-on-blockchain-vs-tangle-vs-hashgraph/
Spielman, A. (2016). *Blockchain: Digitally Rebuilding the Real Estate Industry.* MIT. Retrieved from http://dci.mit.edu/assets/papers/spielman_thesis.pdf
Tissink, A. (Producer). (2017). Circulaire lift bevrijdt markt van verstikkende wurggreep. Retrieved from https://www.cobouw.nl/bouwbreed/nieuws/2017/05/circulaire-lift-bevrijdt-markt-van-verstikkende-wurggreep-101248968
Turk, Ž., & Klinc, R. (2017). *Potentials of Blockchain Technology for Construction Management.* Paper presented at the Procedia Engineering.
ValorisationCentre. (2017). Home of Innovation - A small taste of our cutting edge technology. In T. Delft (Ed.).
Vavilov, V. (Producer). (2016). The Missing Piece of the Internet is Here: 5 Fundamental Facts Everyone Needs to Know About The Bitcoin Blockchain. Retrieved from https://medium.com/@BitFuryGroup/the-missing-piece-of-the-internet-is-here-5-fundamental-facts-everyone-needs-to-know-about-the-6ed5fc6d57a
Voshmgir, S. (Producer). (2016). Smart contracts & dApps. Retrieved from https://image.slidesharecdn.com/dapps-160501121634/95/smart-contracts-dapps-4-638.jpg?cb=1500293639
wikipedia. (2018). The DAO.

Winch, G. (2010). *Managing construction projects : an information processing approach* Retrieved from 123Library http://www.123library.org/book_details/?id=57708

Dawsonera http://www.dawsonera.com/depp/reader/protected/external/AbstractView/S9781444314694

Ebook Library http://public.eblib.com/choice/publicfullrecord.aspx?p=698479

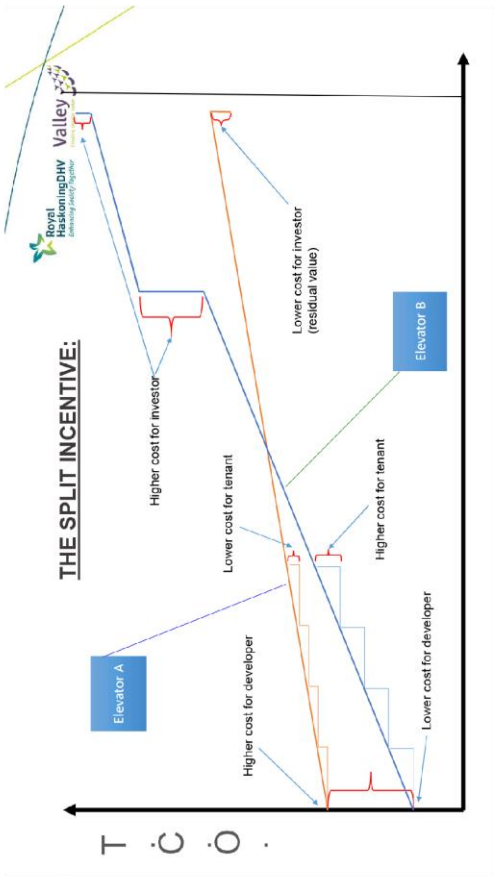
ProQuest Ebook Central http://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=698479

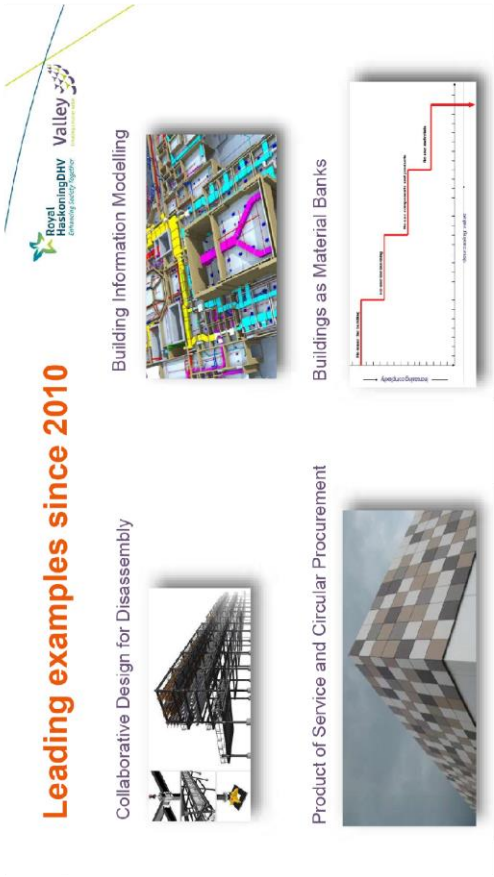
Zach (Producer). (2018). What is Tendermint? Retrieved from https://tendermint.readthedocs.io/en/master/introduction.html

Zheng, Z., Xie, S., Dai, H., Chen, X., & Wang, H. (2017, 25-30 June 2017). *An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends.* Paper presented at the 2017 IEEE International Congress on Big Data (BigData Congress).

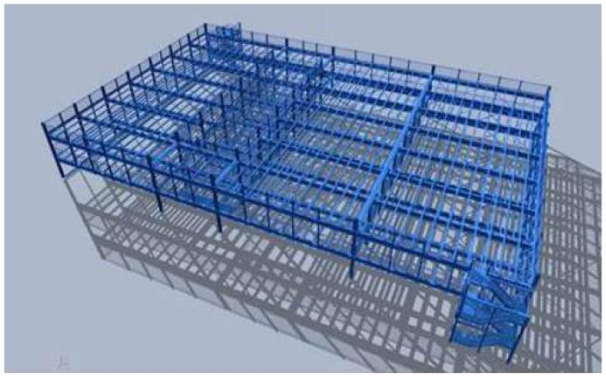
Appendices

Appendix 1 – Further X-Decks details





Staal skelet



Dak

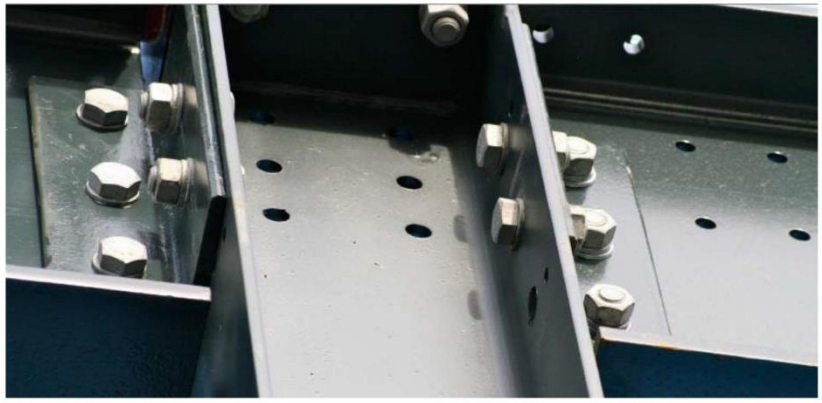
Verdieping

Verlichting

Hellingbanen

Vloerplaat op staalskelet

Assemblage systeem



Assemblage systeem

Assemblageproces

Wensen voor versie 2.0

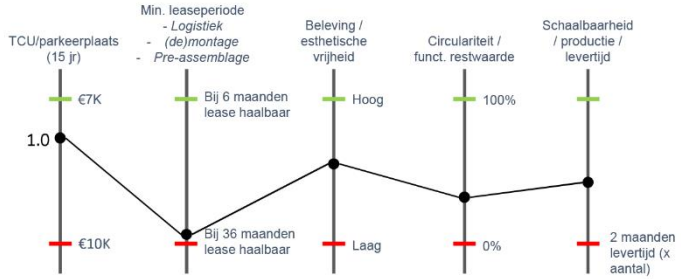
Casus: Parkeerhub Valley (fase 1, 2, 3)

Stap 1: Design Rules

Veiligheid / normen / bouwbesluit

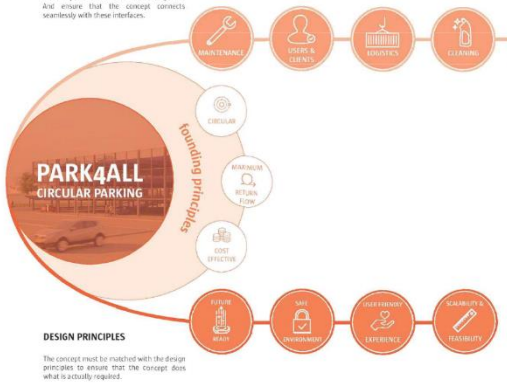
Onder andere:
- *Minimale overspanning*
- *Draagcapaciteit:*
  - *2kN/m2*
  - *1000kN kriklast*
- *30 min brandwerend*
- *Stroefheid*

Stap 2: Weegfactoren



Suggesties oplossingen 2.0

Bijv. vloerdelen NPSP



Appendix 2 – Further blockchain concepts

Stateful and statless systems

Broadly speaking there are two types, **stateless systems** with limited ledger functionality and **stateful systems** which allow for greater on-chain functionality (i.e. smart contracts). Both designs have advantages and drawbacks.

The stateless blockchain system is best represented by its initial form, Bitcoin.
The major advantages of this design is simplicity and fewer attack surfaces. The relative simplicity ensures that less things can happen on the ledger, which in turn means that there is less data on the ledger and better scalability. A drawback however, is that because of this relative lack of functionality, adding more complex logic needs to be done externally (Figure 45).
(UTXO unspend transaction output, that can be used as an input for a new transaction)

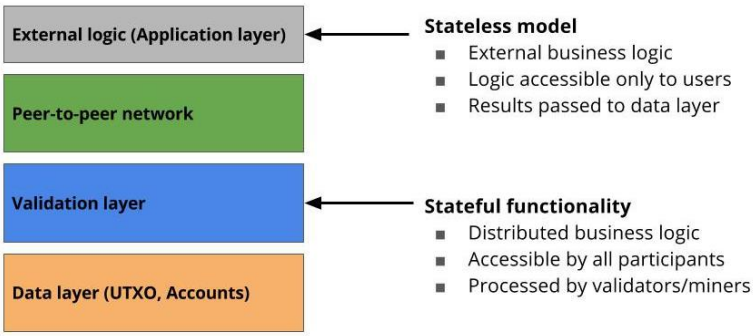


Figure 45. Stateless and stateful systems (Platt, 2017)

On the other end of the spectrum is the stateful model. The best known application is Ethereum. This system allows participants to create nearly any imaginable functionality directly on a blockchain by receiving inputs from the real world and processing it through a so called Oracle. The benefits and drawbacks are the inverse of the stateless system. Firstly, it can be customized to a specific business logic, second, auditing can become easier, assuming all required information is included in code. The drawbacks are that everyone has to process everything which hampers the speed and data scalability, secondly, anyone can look at anyone else's smart contract code and can guess what they will be doing next, which means they can front-run those moves, and attack the application - see the DAO hack (Giancaspro, 2017).

Concluding these information for the X-Decks case; a stateful system is definitely desirable since it offers the opportunity to change and adapt to different transaction models. A stateless system would be too rigid since the tasks, that the blockchain network shall facilitate, shall have opportunity to evolve over time.
Figure 46 gives an overview that categorizes current blockchain initiatives in stateful and stateless.

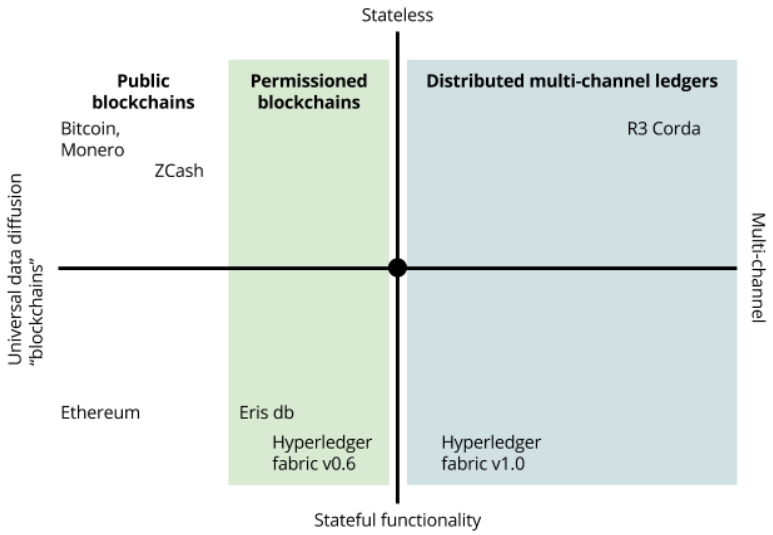


Figure 46. Categorization of blockchain initiatives (Platt, 2017)

Blockchain for business

A blockchains' main functionality is decentralisation, but companies have different interests and different point of views on the benefits that can come along with decentralisation and set the focus on other things like transparency, efficiency, security, etc. Hence, it is more important to see the companies exact requests to meet their requirement.

"Business blockchain requirements vary. Some uses require rapid network consensus systems and short block confirmation times before being added to the chain. For others, a slower processing time may be acceptable in exchange for lower levels of required trust. Scalability, confidentiality, compliance, workflow complexity, and even security requirements differ drastically across industries and uses. Each of these requirements, and many others, represent a potentially unique optimization point for the technology"(Hyperledger, 2017b). Figure 47 summarizes the key components for businesses that want to consider operating their processes on a blockchain network.

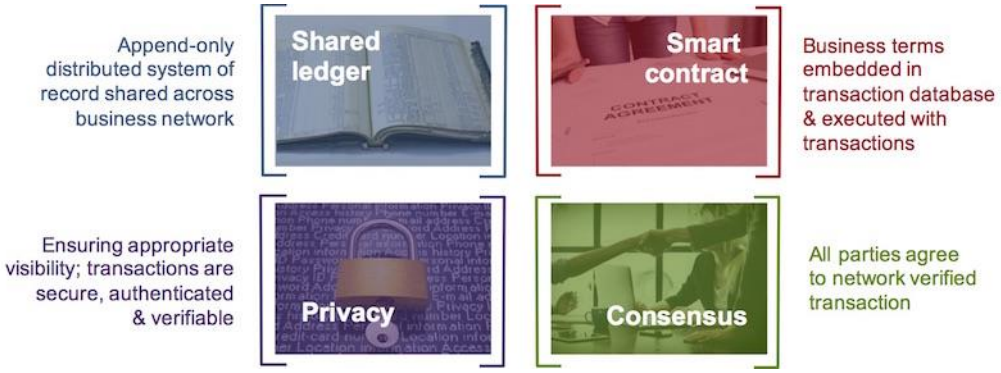


Figure 47. Blockchain for business (IBM, 2016)

the following head points describe the key business blockchain components in Figure 47 in further detail:

- Consensus layer – In charge to generate an agreement on a transaction order and checks the validity of transactions that become part of a block
- Smart contract layer – Handles transactions requests to find out if the transactions are in line with the predetermined business logic
- Identity services – Involves the registration and enrolment process of the different stakeholder identities to ensure that the network is run in a trustable environment
- Application Programming Interfaces (APIs) – Connects the client and application to manipulate a blockchain network.
- Policy services – Since the transactions executed on a blockchain shall become legally binding it is important to agree upon a common endorsement, consensus and group management policy.
- Interoperability - Enables the compatibility between different blockchains. E.g. connecting a permissioned and unpermissiond blockchain or creating channels to filter confidential information for certain parties.

In tackling the these different components towards the needs of a specific business case it is also important to find the right approach in 'open and closed innovation' (Figure 48). On the one side blockchain technology is not matured yet and new standards need to be developed to guarantee an inter industry interoperability. On a smaller scale this interoperability also has to be established within the core consortium of the X-Decks project. Transparency, open-sourcing information, processes and cooperation are here the key. On the other side the business ideas might be confidential and do not want to be shared with competitors, which might be rather hindering at this stage of blockchain development but it has to be considered to find the right balance like the control bar in Figure 48 indicates.

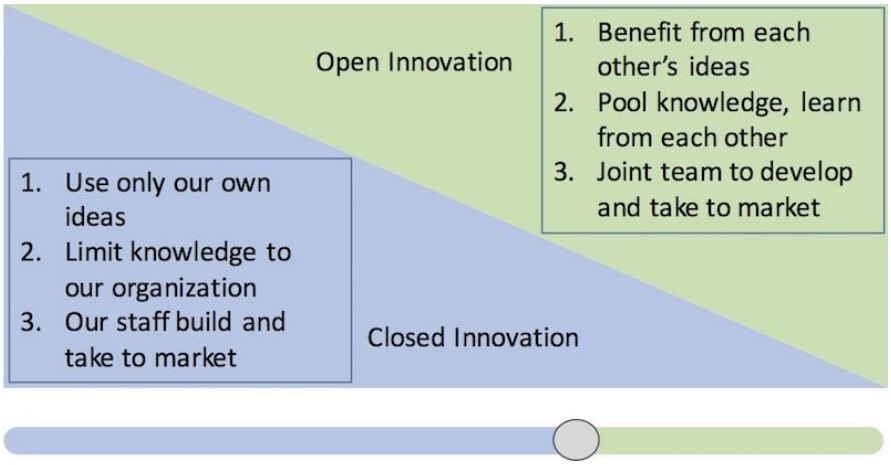


Figure 48. Open / Closed Innovation Slider (Palfreyman, 2016)

ICT in the construction sector

Taking a step back from the blockchain technology it is also interesting to see how Information and Communication Technology is currently operating in the building industry. This sub chapter shall help ,in the further research of this thesis, to locate the possible blockchain enabled impact in the X-Decks case to current technology standards.

In Figure 49 the ICT systems are separated in 'Engineering information management systems' (EIMS) and 'Enterprise resource management systems' (ERMS). Broadly speaking there are four main modules available in most ERMS, which move beyond purely resource base management issues to address project management issues:
Supply chain management, Knowledge management, Project management and human resource management (Winch, 2010)
The intensions of establishing a blockchain in this thesis comes closest to the Electronical Data Interchange(EDI in Figure 49). These are central to the development of B2B e- commerce systems, which largely automate the processes of ordering, logistics and invoicing between members of the supply chain.

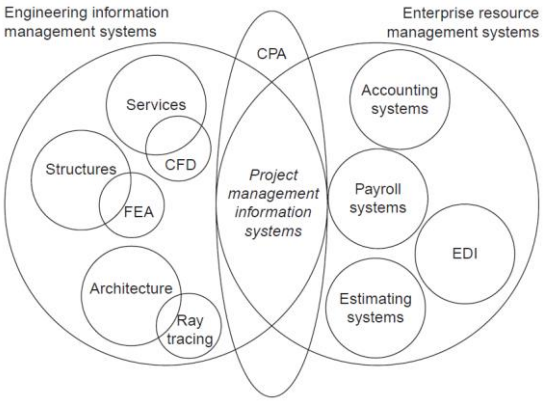


Figure 49. ICT systems for construction project Management (Winch, 2010)

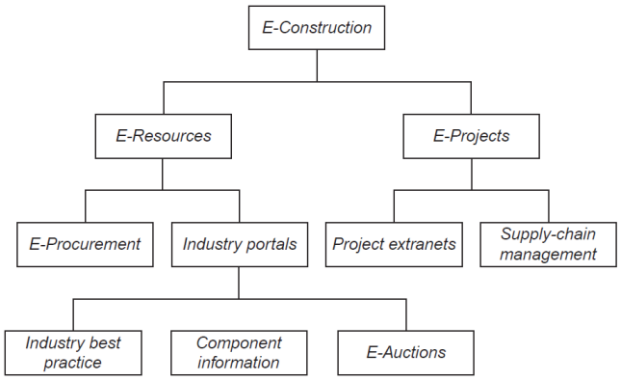


Figure 50. E-construction(Winch, 2010)

For a construction project in Figure 50 there are different disciplines in the field of E-Construction. Similar to the EDI system, the supply-chain management branch comes the closest to the propose of bockchain in this thesis. Supply chain management represents here the horizontal dimension of the project coalition. In addition to considerably reducing the transaction costs associated with the administration of commercial relationships, ERMS supply chain applications can be used to meet the information requirements of lean production on a sell one, make one, buy one basis. Sophisticated optimisation algorithms can also be used to analyse the information generated
by the system to improve decision- making.

Current ITC state in the building industry

In particular, most ERMS were not designed for project based businesses, yet **it is usually necessary to adapt to the system rather than adapt the system to the business because of the high costs of customisation.** The change to a ERMS implies a fundamental business change. Still, there is a significant number of construction firms like Davis Langdon, Arup or COWI who adapted.
Others prefer to use COINS (Construction Industry Solutions) which provide business process specific integration modules for builders, civil engineering contractors, housebuilders and specialist contractors. Which is better suitable for smaller firms who want to stay agile.

SAP, the German software company, is the global leader in ERMS, and claims some 1500 customers worldwide in the construction sector, although most of these are in the engineering construction and equipment manufacturing sub- sectors. Within the SAP Engineering, Construction and Operations

industry solution there are three configurations focused on project management, procurement and facility management. These tend to be focused very much on estimating, cost planning, cost control and resource management. Interfaces are available with Primevera and BIM systems supplied by Autodesk and Bentley. The high costs and generic nature of ERMS has left a niche market for construction specific ERMS such as COINS.

The blockchain network for the X-Decks case shall also be customized to the business case with interoperability links to scale up the network possibly for more stakeholders than just a core consortium. The rigidness of ERMSs shall be kept as low as possible when adapting to a blockchain network but considering the quite disruptive change of processes, probably it cannot be integrated as smoothly as a COINS.

Blockchain providers

The field of blockchain providers is rather confusing because of its novelty and by now there are no best practice cases established besides Bitcoin. This is why the following overview shall give an insight for businesses about current blockchain based service providers.

Infrastructure provider
The first type of blockchain-based business models is the infrastructure provider. Here, a database and a decentralized storage location is realized through blockchain technology, without further functionalities. Customers of infrastructure providers consequently stay passive and no further applications can be independently based on this digital infrastructure. The remuneration structure of this business model is mostly based on subscription or rent of the storage space or accounts. Accordingly, the remuneration shall be calculated on the basis of the actual transactions, after the storage of data. An example of this type of block-based business models is the German start-up company "BigChainDB".

Platform provider
Platform providers are similar to infrastructure providers, however, these allow an independent development of functionalities and applications by the (active) customers. Thus, for example, Apps are programmed based on the blockchain, without knowing all the technical characteristics of the technology. The blockchain becomes here a "black box". Profit for the platform provider is made by a license or account-based payment after the subscription during the development of the application. Platform providers also provide consultancy services, an example is the platform "Multi Chain".

Integrator
Integrators offer services to customers as well as process-specific applications and the implementation. Customers of this type are block-based business models are mostly end-users, such as companies that need a blockchain-based application for a specific company purpose as well as, for example, authorities or providers of public infrastructures. Accordingly, the adaptation of the blockchain-based applications is either a account- or license-based remuneration models.
Just as with the platform providers consultation of the costumer plays an important role. An example of an integrator is the company "Factom".

Application provider
Application providers offer ready-made applications without the possibility of customization for the customer. Accordingly, customers remain mainly passive end customers. A typical example for such an applications are payment services, such as "Fuzo", where transactions on the blockchain are executed without the involvement of central authorities. Consequently there is a large number of potential applications and the payment models range from transaction-based models to sale of licenses.

Provider of complementary services
The supplier of complementary services or products, is basing the company only partly on blockchain technology. Frequently these services are information services as in the case of the company "Blockchain University", whose task in to spread knowledge about the new technology.
Mostly, these companies are charitable, financing themselves through consultation or revenue sharing with partner organizations.

Now that the different providers are categorized let's take a look at some concrete initiatives in the blockchain for the business cosmos that provide promising infrastructures for the building industry and the X-Decks case. Most parts of the following descriptions are directly adopted from the referenced sources. Hence I do not claim this part to be my work.

Hyperledger
"The arguably biggest player of in the field of permissioned blockchains is Hyperledger Fabric. Hyperledger is the umbrella open source project that The Linux Foundation and IBM have created and hosted since 2015. It aims at advancing and promoting cross-industry blockchain technologies to ensure accountability, transparency, and trust among business partners"(Paul, 2018).
These benefits are valued by leaders across many industries, including technology, finance, healthcare, supply chain, and automotive, among several others.(Linux, 2017)
"Rather than an open permissionless system that allows unknown identities to participate in the network, requiring protocols like Proof of Work to validate transactions and secure the network, the members of a Hyperledger Fabric network enrol through a Membership Service Provider (MSP).

Hyperledger Fabric also offers several pluggable options. Ledger data can be stored in multiple formats, consensus mechanisms can be switched in and out, and different MSPs are supported. Hyperledger Fabric also offers the ability to **create channels, allowing a group of participants to create a separate ledger of transactions**. This is an especially important option for networks where some participants might be competitors and do not want every transaction they make - a special price is offered to some participants and not others, for example - known to every participant. If two participants form a channel, then those participants – and no others – have copies of the ledger for that channel" (Linux, 2017).
"For these reasons, Hyperledger incubates and promotes a range of business blockchain technologies including distributed ledgers, smart contract engines, client libraries, graphical interfaces, utility libraries, and sample applications. Hyperledger's umbrella strategy encourages the re-use of common building blocks via a modular architectural framework.
This enables rapid innovation of distributed ledger technology (DLT), common functional modules, and the interfaces between them. The benefits of this modular approach include extensibility, flexibility, and the ability for any component to be modified independently without affecting the rest of the system."(Hyperledger, 2017b)

Another promising initiative in the field of private blockchains is **Tendermint.**
"Tendermint consists of two chief technical components: a blockchain consensus engine and a generic application interface. The consensus engine, called Tendermint Core, ensures that the same transactions are recorded on every machine in the same order. The application interface, called the Application BlockChain Interface (ABCI), enables the transactions to be processed in any programming language. Unlike other blockchain and consensus solutions, which come pre-packaged with built in state machines (like a key-value store, or a scripting language), developers can use Tendermint for BFT state machine replication of applications written in whatever programming language and development environment is right for them.
Tendermint is broadly similar to two classes of software. The first class consists of distributed key-value stores, like Zookeeper, etcd, and consul, which use non-BFT consensus. The second class is known as 'blockchain technology', and consists of both cryptocurrencies like Bitcoin and Ethereum, and alternative distributed ledger designs like Hyperledger's Burrow.
Tendermint emerged in the tradition of cryptocurrencies like Bitcoin, Ethereum, etc. with the goal of providing a more efficient and secure consensus algorithm than Bitcoin's Proof of Work.
Tendermint can be used as a plug-and-play replacement for the consensus engines of other blockchain software. So one can take the current Ethereum code base, whether in Rust, or Go, or Haskell, and run it as a ABCI application using Tendermint consensus. Indeed, this was done with Ethereum and it is planned to do the same for Bitcoin, ZCash, and various other deterministic applications"(Zach, 2018).

Tendermint and Hyperledger Fabric

"Fabric takes a similar approach to Tendermint, but is more opinionated about how the state is managed, and requires that all application behaviour runs in potentially many docker containers, modules it calls "chaincode" – which are smart contracts. It uses an implementation of Practical Byzantine Fault Tolerance (PBFT) from a team at IBM that is augmented to handle potentially non-deterministic chaincode. It is possible to implement this docker-based behaviour as an Application BlockChain Interface (ABCI) app in Tendermint, though extending Tendermint to handle non-determinism remains for future work"(Zach, 2018).

Ethereum, as already addressed in the Chapter 'stateful and stateless systems' belongs to the stateful systems. Which mean that is provides a fully programmable API on an unpermissioned blockchain. This makes it a much more agile system than the Bitcoin blockchain and opens up countless possibilities to experiment with own ideas. It is an open-source project that provides the cryptocurrency Ether. Ethereum has a higher throughput and lower latency than Bitcoin and enjoys the benefits of a large community with reams of tutorials. It is planned to move the consensus algorithm from proof of work to proof of stake to improve scalability and energy consumption of the network. Considering that large projects like the DAO that tried to apply smart contracts on a bigger scale failed miserably (wikipedia, 2018), Ethereum shall be still seen as an experimental ground rather than a commercially exploitable platform.

Ripple Ripple does for payments what SMTP did for email, which is enable the systems of different financial institutions to communicate directly with each other. "The consensus algorithm utilizes collectively-trusted subnetworks within the larger network. In the network, nodes are divided into two types: server for participating consensus process and client for only transferring funds. Each server has an Unique Node List (UNL). UNL is important to the server. When determining whether to put a transaction into the ledger, the server would query the nodes in UNL and if the received

agreements have reached 80%, the transaction would be packed into the ledger. For a node, the ledger will remain correct as long as the percentage of faulty nodes in UNL is less than 20%"(Zheng et al., 2017).

R3 Corda, as of September 2017, R3 is a consortium of over one hundred large global financial institutions, that seek to leverage distributed ledger technologies to record, manage, and automate legal agreements between businesses through its software solution, called Corda. Corda is a distributed ledger platform, which features a blockchain-style P2P network; however, it is not a blockchain platform. Unlike blockchains, which involve global availability of data across the network and third party validators, Corda only allows information access and validation functions to parties actually involved in the transaction. Featuring a different software architecture, *"Corda achieves consensus between firms at the level of individual deals, not the level of the system"* (Richard Gendal Brown, 2016), while supporting a variety of consensus mechanisms.
Distributed ledgers, must have a ledger, which multiple parties use, and is stored across multiple locations. A blockchain combines that, but where they differ from Corda is how much they share and with whom they share that.(Platt, 2017)

Created by JPMorgan, **Quorum** is, in fact, a fork of the Ethereum public blockchain, which uses a voting-based consensus algorithm to facilitate an enterprise-focused distributed ledger and smart contract platform. Data privacy is achieved within the network by allowing data visibility on a need-to-know basis. The platform is designed to support *"both transaction-level privacy and network-wide transparency" (Morgan, 2018)*. The network validates all smart contracts and overall system state through the involvement of all running nodes. As with other permissioned ledgers, regulatory compliance is front and center in the Quorum platform.

The cryptocurrency **IOTA** has been around since 2015. According to Martin Rosulek, *"It is the first cryptocurrency that provides the whole ecosystem based on blockless blockchain"* to enable machine-to-machine (M2M) transactions (Popov, 2017).
"IOTA, however, is more than just a cryptocurrency. Essentially, the platform entails a generalization of the blockchain protocol (the technology called Tangle) that sits at the backend of the IOTA platform. Instead of paying miners to validate the transactions, the architecture of the network involves peer-based validation. We can think of a simple analogy, that of a teacher grading students' homework: the students are the clients/users in the Bitcoin protocol, and the teacher is the miner/validator. Tangle technology asks students (users) to grade each other's homework, making the need for a teacher (external validator) redundant, and avoiding expenses related to the teacher's/validator's work. This allows the platform to be completely free of cost, without facing the scaling challenges that are inherent in the first generation of blockchains." (Paul, 2018)

Summary

The chapter blockchain providers categorized different levels of service providers in the blockchain for business cosmos. From just infrastructural support to all-in-on blockchain as a service there is everything available. Especially the secondary got to be handled with care since blockchain processes are not fully deployable yet in a business environment, but some providers are promising that already.
The blockchain initiatives described in the second part represent a similar bandwidth. The most promising initiative related to the X-Decks project is the Hyperledger framework since it is focused on an inter industry compatibility and promotes an open-source, community driven playground to link company specific use cases with first blockchain pilots.

Appendix 3 - Interview Questions

Stakeholder business and information flows

1. What was the main problem or need that is covered by your company's product or service (for the X-Decks project)?
2. How were you contracted and paid – can you describe the process looking back at the last three projects you have worked on /the last three contracts that you signed with contractor/investor?
3. What kind of information and assets were stored, monitored and transferred, and which technologies were used to do so? (especially paper bases ones)
4. Which partners were important for your own business model?

Blockchain

5. Were there any blockchain related projects at your company? If no: What do you know about blockchain technology? Did you heard about any applications (in building industry)?
6. Did you ever got the chance to invest materials or working hours to hold shares of a building project?

-> Presentation of blockchain principles and a first outlines of a blochchain enabled business model for the X-Decks case.

7. What did you think of the suggested process via blockchain technology?
8. What kind of barriers or roadblocks would you imagine in the blockchain space?
9. Do you see other opportunities that can benefit from blockchain technology?

   (check if any KPI's have been unmentioned)

10. Any additional comments, things that have been missed?
11. Permission to use project name, company name, and name of interviewee for the thesis publication?

Blockchain enabled business opportunities in the case of X-Decks

Thesis Research Interviews
Benjamin Weihs

TUDelft Royal HaskoningDHV

1

Interview Questions

Can I record this interview session?

Stakeholder business and information flows

1. What was the main problem or need that is covered by your company's product or service (for the X-Decks project)?
2. How were you contracted and paid – can you describe the process looking back at the last three projects you have worked on /the last three contracts that you signed with contractor/investor?
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4. Which partners were important for your own business model?

Blockchain

5. Were there any blockchain related projects at your company? If no: What do you know about blockchain technology? Did you heard about any applications (in building industry)?
6. Did you ever got the chance to invest materials or working hours to hold shares of a building project?

-> Presentation

7. What did you think of the suggested process via blockchain technology?
8. What kind of barriers or roadblocks would you imagine in the blockchain space?
9. Do you see other opportunities that can benefit from blockchain technology?
   (check if any KPI's have been unmentioned)
10. Any additional comments, things that have been missed?
11. Permission to use project name, company name, and name of interviewee for the thesis publication?

2

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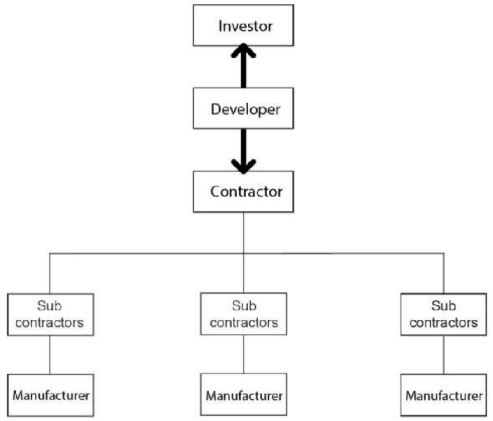

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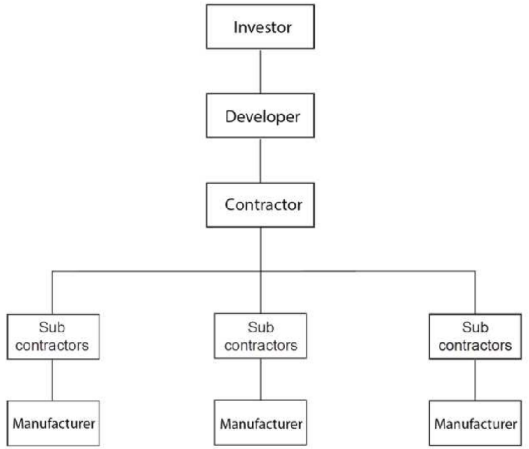
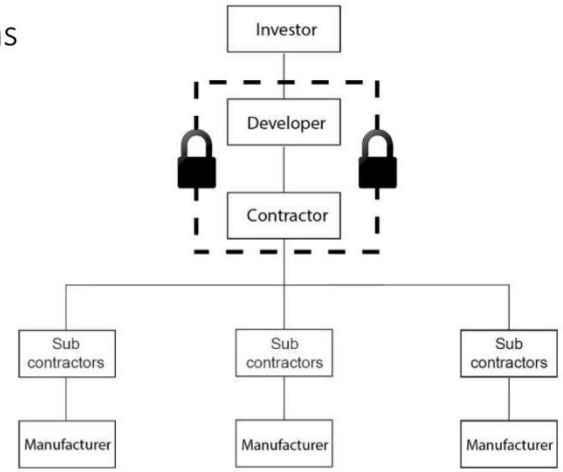
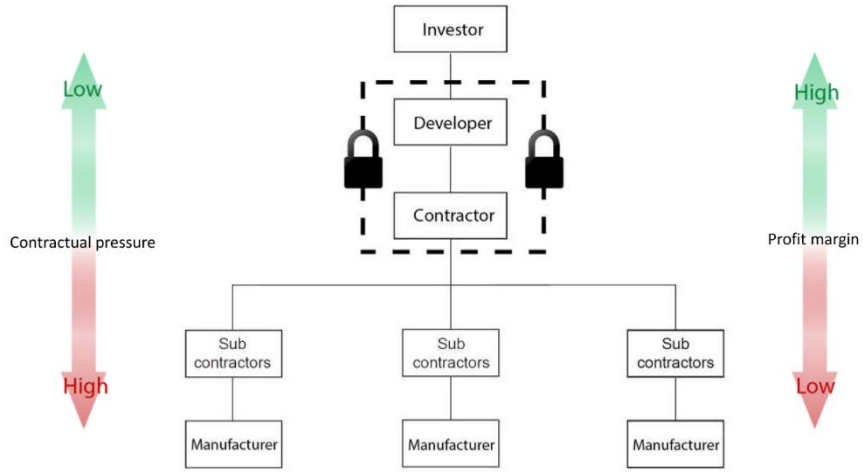


4

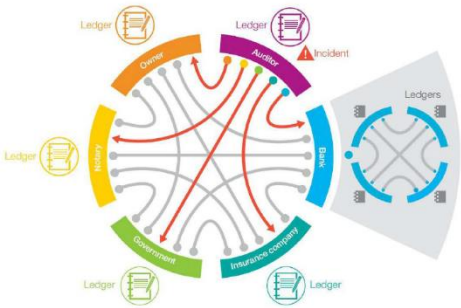
Frictions





Frictions

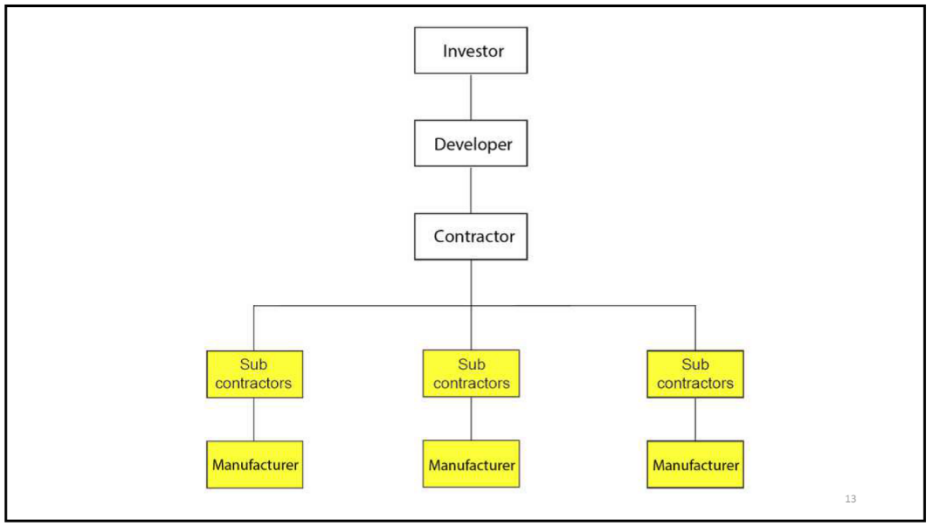
- Construction execution varies in duration, which creates uncertainty. Independent **decision makers at the resource-base level tend to act in their own interests rather than in the interests of the collective**.
- **Exposing information** about costs and revenues to external stakeholders**, can easily turn into competitive disadvantages**
- Suppliers have information that is critical for effective client decision-making, but are **not motivated to fully share that information** (Winch, 2010)
- Buyers cannot easily monitor the quality of the goods or services received, and so **suppliers are tempted to substitute lower quality goods** or be less than diligent in the supply of services.

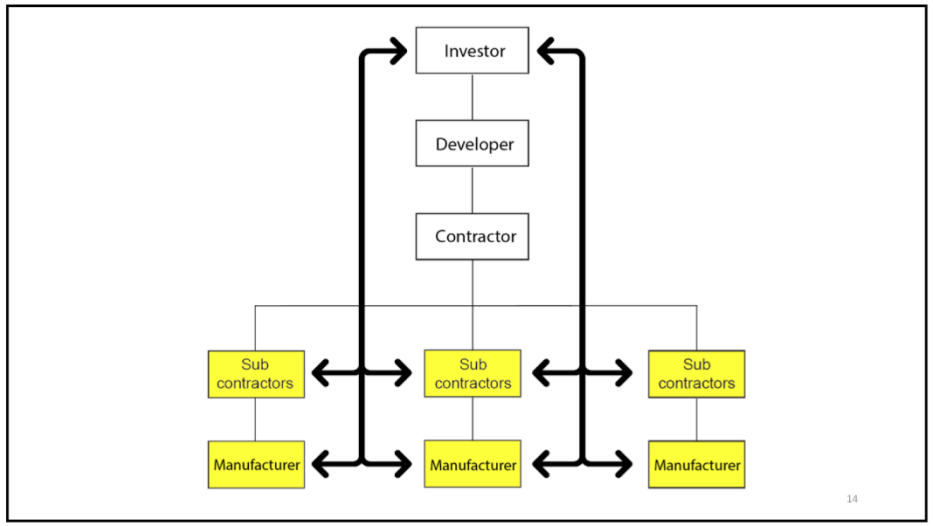


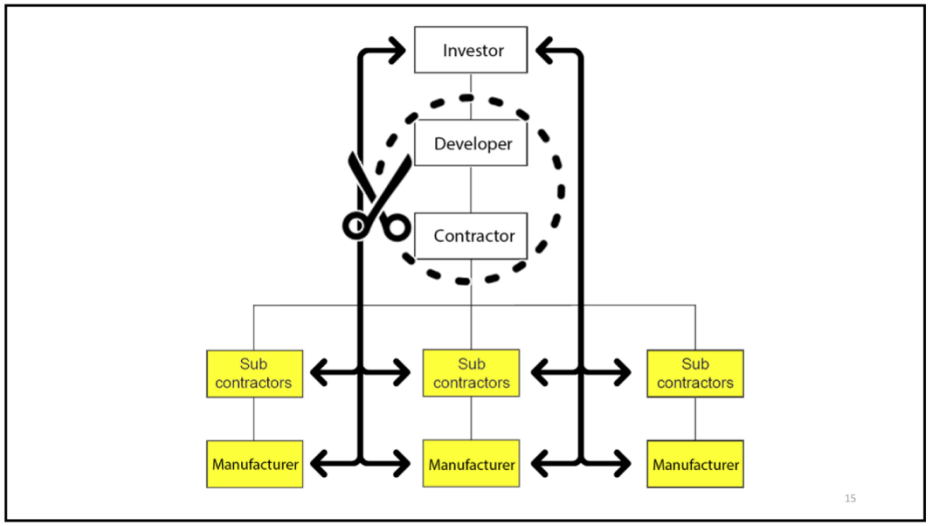
Individual ledger

Shared ledger

IBM (2017)


Investor
Developer
Contractor
Sub contractors
Sub contractors
Sub contractors
Manufacturer
Manufacturer
Manufacturer
13


Investor
Developer
Contractor
Sub contractors
Sub contractors
Sub contractors
Manufacturer
Manufacturer
Manufacturer
14


Investor
Developer
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Sub contractors
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Manufacturer
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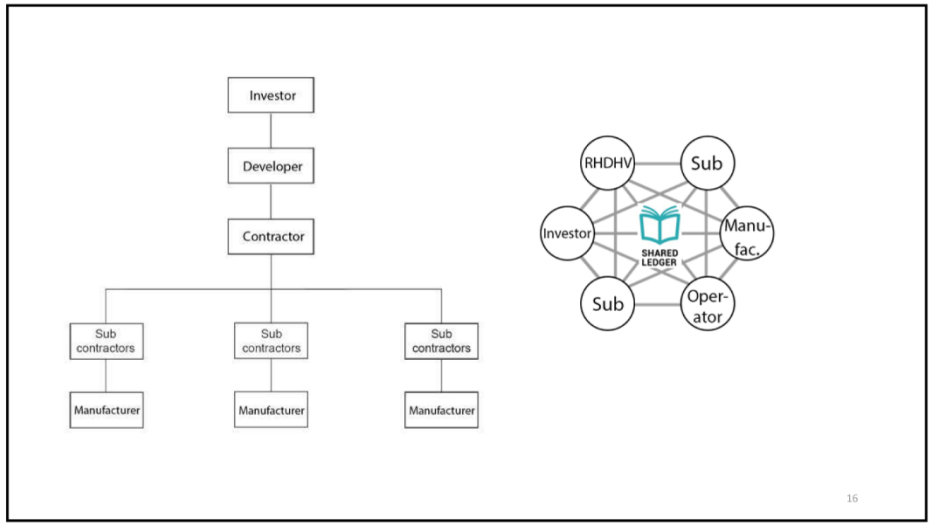
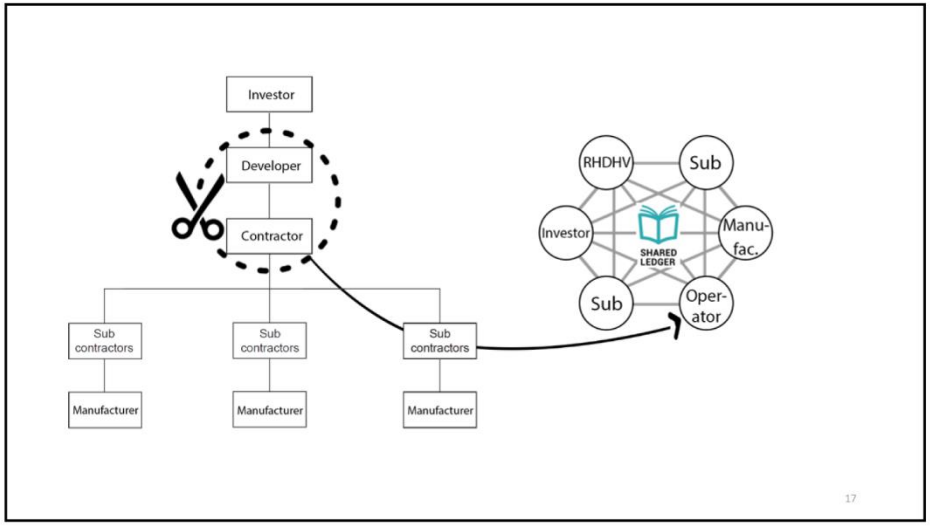
Manufacturer
15


Investor
Developer
Contractor
Sub contractors
Sub contractors
Sub contractors
Manufacturer
Manufacturer
Manufacturer
RHDHV
Sub
Investor
Manu-fac.
SHARED LEDGER
Sub
Oper-ator
16


Investor
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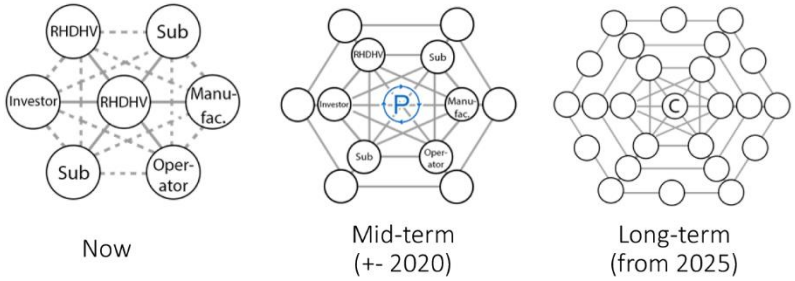
RHDHV
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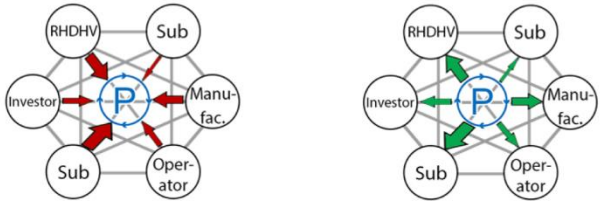
RHDHV
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Investor
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Oper-ator
Investment
Revenues

19


Users
Maintenance
Scrap Merchant
Operator
Subs
Contractor
npsp
omu
Royal HaskoningDHV
Focus Group
PHILIPS
BRINK

20

Aims

- Tear down organizational silos through a new business approach that **strengthens the position of manufactures and suppliers**
- Blockchain deployment: Design a business model where information and **transaction flows can be shared successively more transparent and automated**
- Investigate into the external stakeholders' willingness to adapt to a blockchain enabled business model;
- Enable a more flexible, short-term leasing concept for parking space in the Netherlands

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BUT

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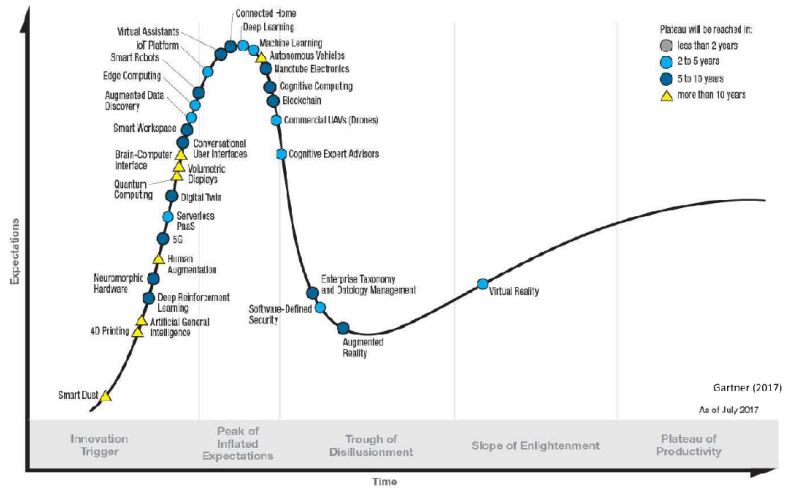

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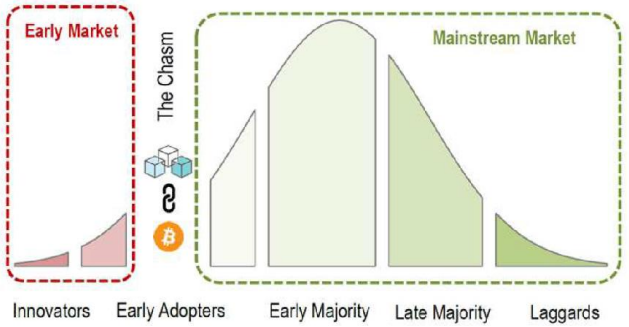
Scientific relevance



Brennan(2016)

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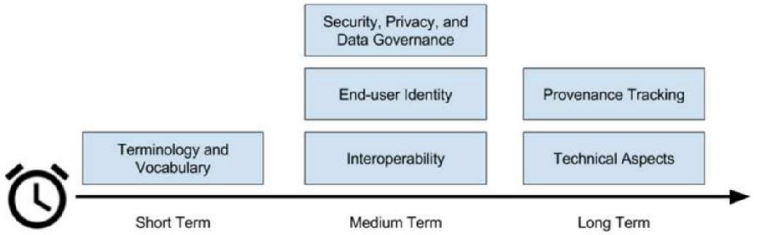
STANDARDS ROLE IN SUPPORTING BLOCKCHAIN/DLT



Linux Foundation(2017)

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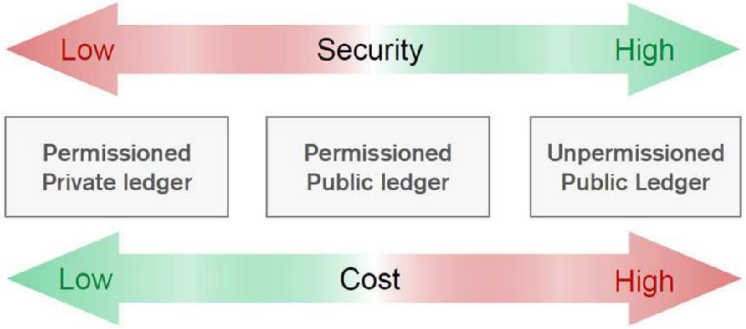
Cost vs Security tradeoff of blockchain types



Credit Suisse Research (2017)

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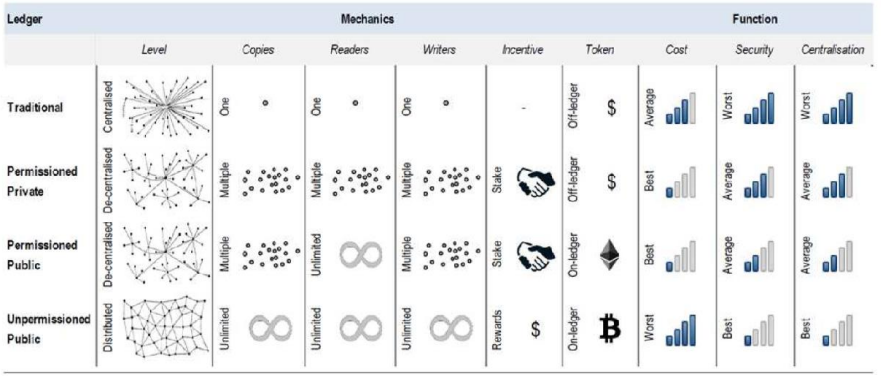
Leveling the ledgers



Credit Suisse Research (2017)

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Appendix 5 – Main findings interviews

The main findings are derived from Appendix 6 - Interview Transcripts, where the interviews can be found in full length. The findings are organized in following tables. The first table "Responsibilities of stakeholders" summarizes, mainly in quotes, the role and responsibilities of the particular stakeholder from their own perspective as well as from the perspective of the other stakeholders.

Topic	Interviewee	Responsibilities of stakeholders
Role of developer	RHDHV Delta	The developer takes the biggest financial and organizational risk in the building process
Role of investor	Delta	Pension funds take over long-term commitment to operate a building
Role of RHDHV	RHDHV	Engineering consultancy firm that is making first steps towards developing recurrent business models like X-Decks. Currently most turnover is made with one-off consultancy services "We [RHDHV] are still not doing enough on business to business towards investors. We [RHDHV] should more focus on that"
Role of municipality	Delta OMU	Long-term commitment and supportive regulations for innovation
Role of manufacturer	Metsä	"We sell birch plywood, to contractors or distributers…we want to focus on wood production, the shareholders of Metsä are forest owners. We are a cooperation of forest owners and they also own the company. All the actions we do must be in interest of the shareholders."
Role of contractor	TBI	"What we as a contractor want is of course investing, build and get our money back. And to get out as fast as possible because we need [the money] to build again."
		"In the Netherlands there are a lot contractors who combine development due diligence with contracting…we also do that in couple of projects in that sense we can be one party in the organigram too. In 90% of our projects it is completely different."
Roles of OMU Investor + public party	OMU	OMU takes over the roles of a financier, investor or advisor. "We do not know at this moment which of these three roles we will play" at X-Decks. OMU "makes sure that government and private sector work together better" but "we do not have the final responsibility"
		Reduction of parking spaces is required by policy makers as well as well as by society. "we do not want to build for vacancy"
		"We do stimulate circular developments, through zoning, regulations, policies, sharing knowledge but…but our own role is really for the short-term"

Table 5. Interview findings Responsibilities of stakeholders

The following findings “Business and Information Flows” summarize current business models of the stakeholders. Beyond that the financial and information flows that are necessary to support the business model are observed.

Topic	Interviewee	Business and Information flows
Current financing	RHDHV	Parking decks of Park4All (predecessor of X-Decks) have been bought directly by the costumer, there was no external or upfront financing necessary, although there is support of a private investor who is involved with 15 million Euro that was not needed by now.
Failure costs	Delta	A reservation of 20% for failure costs is usual
Timely horizon		Horizon for circular / leasing projects: “Anything that can be arranged from 3-15years is doable in today’s climate”.
Business model	OMU	Funded by the province with 15 million Euro. Lend money and cover their own costs by interest rates on the back-payments. OMU “makes every year a bit of loss” - Societal mission is more important than commercial interests. 1-3 years is our current investment period – everything beyond is rather difficult.
Ways of selling	Metsä	1st “we do pool marketing. So we have contact with engineers and architects. They prescribe our products and then there is a tender phase, where the builders (contractors) ask for a price and we guide them to our partners. Then they order from the partners.” 2nd Selling through partners who actively work with the products of Metsä 3rd “Clients who approach us through online research”
Business focus		“We are less involved in projects so we are more focusing on delivering…I think we are currently changing more to a supplier. We try to work and invest more into partners. Not just for a single project but in partner e.g. for modular buildings.”
Shares		“We do not just want to send an invoice but we want to be partners. It is a totally different approach but when I am thinking about it I see it also happening now [at Metsä] ”
Capacity	TBI	“I agree that it is steadily moving towards more collaboration and it does not matter with whom but it should always be with one party that has a strong capacity. If something fails they need the capacity to keep the processes going otherwise everything collapses.”
One company, many subdivisions		“If you look at our ecosystem we are one shop with different flowers… What we want as TBI is to see each other as a network organization, with different parties best for one project.”
Slow adaption		“We know there are new technologies which are rapidly expanding and creating new markets but at the other hand in our business there was little change in the last two to three years.”
Profit margin in the organigram		“The profit margin is decreasing if you go back in the supply chain is not true.”
Contractual pressure in the organigram		“It depends on the market. When we are in the crisis and the investor has all the power it might be true but now the building economy is going up, now we are not at the top yet but when it happens then the manufacturer is on top. So it depends on the economic situation.”
Relation to	TBI	“We do not want to be locked to one manufacturer, we want to let the market work. Because it

manufacturer		is not that easy to have one manufacturer constantly as the cheapest."
Relation to contractor	RHDHV	"We do not want to be locked to one contractor. So it is about does he has the power to do it now or is he going back or not? There can be all kind of reasons not to work with a party at a certain moment. Maybe you have new innovations that is why you do not want to work with them anymore…"
Information flows	RHDHV OMU	Contracts and are mainly communicated paper based or per email. First attempts to move to the cloud are made.
	OMU	Excel for budgeting, cost analysis and surveying. Dropbox to share documents. GIS for lead pipeline projects, an interactive system where data is shared with the municipality and province.
	Metsä	"Within our own CRM there is a project database and there I store all the projects. It is all internal."
	Delta	The main source of information is BIM – but real time management is not there yet

Table 6. Interview findings Business and information Flows

Innovation & Frictions

Table 7 and Table 8 summarize innovations as well as frictions that are happening within the business model of the stakeholders, in the build environment in general as well as in connection with the X-Decks project. Frictions can be seen at the same time as needs for improvement.

Topic	Interviewee	Innovation
Circularity	RHDHV	''In our case (Park4All) all the parties collect the materials themselves at the end of the lifecycle.''
	Delta	"It is not just about looking into circularity and modular design for the sake of flexibility but to increase the value of the property."
	C-Creators	"The circular economy is about creating transparency in the complete value chain"
Transparency	Delta Metsä	Collaboration the only way to reduce risks -> race for quality/higher residual value instead for the lowest price.
	Delta	Transparent and fixed profit margins for all stakeholders - this can strengthen cooperation and lower failure costs
Back-to-back contracting	TBI	"So if we go back-to-back risks go more down in the chain. Then they want a higher profit margin. So it also depends on how you contract your subcontractor."
Parking/building as a Service	RHDHV Delta OMU	Sell services rather than products, to enable long-term commitment and profit sharing

	TBI	"Normally [developers] say we design, build and sell – the quicker the better. But now they are also looking at revenues through recurrent services in the service world."
	RHDHV TBI	"services can be added to your garage; do you want your car to be washed, or deliveries put there, flowers…when you come back."
Business innovation	RHDHV	"we are working on scalable products instead of hours that is a new way of doing business for us"
Mobility as service	OMU	Move from individual mobility to shared mobility; carpools, coupons for public transport.
Need for flexible parking solution		Parking spaces are expensive, a flexible parking solution can adapt to the actual demand and gradually scale the amount of parking spaces down, especially in newly developed urban areas where an 'adaption phase' of scaling parking spaces down is needed.
Flexibility		"It [X-Decks] buys you flexibility for a period of 5-10years. In the meantime you have this affordable hub and if it does not work you can move it to next site."
X-Decks		"We buy the land and make sure there is an X-Decks for 3-5years… It is an interesting business case for us."
	TBI	"I am always looking at the moment when these worlds maybe come together. We talked about X-Decks earlier already and the blockchain application on that is worthwhile and we are also very open about the opportunities in there. "
	RHDHV	"So that we create a really flexible system where Metsä can stay owner of the floors. If there is some need for a garage we will create one, so that it is really easy to build in one week and if there is no usage anymore we can take it away."
		"X-Decks is a proof of a concept for thinking about more service orientated buildings."
Prefabrication	Metsä	"Prefabrication is here a key. We are chancing more to off-site working. We see that there is a change now towards modular building. And we think that our ecosystem within 10-20 years there is not enough labour… So there will be more prefabrication that is sent to the building site to have time and failure savings. So we change."
		"We want to add value for higher margins so we add special fillings to out birch ply, we are evolving our ply woods with higher fire resistance, load bearing…"
Replacement of middlemen	RHDHV	"So can we replace them (developer/contractor) by working in another way together? This is the question. Because currently they take all the risk and profit. So it is not distributed to the parties who really create the building."

Table 7. Interview findings Innovations

Topic	Interviewee	Frictions

Collaboration between stakeholders	RHDHV	Subcontractors have often a limited overview of the whole building process – they usually give a guarantee just for their contribution
	Metsä	"…that kind of companies who think about changing it [to collaborative design] in the beginning are in the end mostly too expensive"
	TBI	"You can make it transparent at least you can try to. But it is not something that you can plan upfront, it depends on the subcontractor or manufacturer. There are some easy reasons; are they overloaded or not? Can the manufacturer produce enough glass or do they have another subcontractor who can do the job? So transparency is nice but I do not know if it can be predicted or made more transparent. For the basis these are very banal things. They do business with each and look where there are the cheapest prices and where it is more expensive and if those parties are not constantly working together but just because there is good price at the moment – I think more transparency would not really make a difference here."
Circularity/ Financing structures	Metsä	"very ambitious, low-energy, circular [projects] and then you see that they [parties responsible for tendering] change their mind when they see prices. It does not matter if our price can be lower but often they do not see that you can earn money with this kind of products over the lifecycle of a building."
		"It would be important if we could offer a circular system where we could take back the goods at the end of its lifecycle. But currently we cannot do it."
	Delta	Technological solutions for circularity are there but the investment structures are working against it
Client preferences	RHDHV	"All clients for real estate want to have one company, preferably a big one, financially sound, who says we are doing it for you for this amount of money and this brings the hierarchy."
Manufacturers / Suppliers	RHDHV Delta	Manufacturers, Suppliers and Subcontractors are crucial to collect data from the very beginning of the building process but they have little interest/incentives to commit themselves to the 'bigger picture' of the building process – they usually care just for their own contribution.
Market fluctuations	TBI / RHDHV	"When you look e.g. at Kuijpers who agree on a upfront defined price and these prices variate because they give a price guarantee and that might bring them into trouble to stay competitive when the market changes…these are the hardest times"
Risk management	TBI	"Yes, of course from spending 100%, 20% goes to risk management. Is this a logical model – no! But it is still the best we can think of for now."
Irrational factors	TBI	"Sometimes it is really irrational. A developer might get things done by a certain municipality because he has some other chain project there"
BIM	Delta	BIM information cannot be fully transferred in a spreadsheet yet
Conservatism	Delta	"This is how we always have done it!"

	OMU	Most employees like to work rather old-fashioned.
	Metsä	"In general there is not much transparency. The building sector is always saying that they are motivated to develop new solutions, I doubt wheatear it will happen we see it daily with our materials – it is very traditional, especially in the Netherlands."
Mutable data	RHDHV	"The information builds up on each other. And that is really what we are trying to do manually but it really never worked. Information was left out, sometimes by purpose. Fraud is really easy."
	Delta	**"**If information is not shared then by definition it will divert over time. By definition! Even if you try that it not happens. Information gets lost, misinterpreted.**"**
Organizational silos	Delta	"People are locked into this idea that you need to keep your knowledge to be unique so that only you make profit from it."
	TBI	Silos within the company "We all have different business models within our company"
		"If you look at a façade and the subcontractor has a very good connection to the manufacturer of the glass, they buy a lot of glass from them so they are really integrated. They are even more integrated than the contractor with the subcontractor. So if there is a "lock" it is there."
	OMU	"Everybody thinks that if the X-Decks would work it will be amazing but it does not fit into our usual scope of work." The province judges the work of OMU by revenues and transformed square meters – X-Decks "does not tick all the boxes."
	RHDHV	"The dilemma of cooperating with classical developers in the case of X-Decks is that they say we want it – how much does it cost? We say no – what does it deliver? And they say that is not your business – I want your product as cheap as possible. So it is not about sharing."
Frictions with current business model (Park4All)	RHDHV Metsä	Holding shares requires manufactures, subcontractors to estimate development risks/liabilities – this is often not within their competences
	RHDHV	Leasing not common for parking spaces as it is in the office market.
		When the project is sold the opportunity to create stronger collaboration and shares for the stakeholders is lost.
		"We saw that many more clients would like to have a flexible parking solution. They have the demand but not really the horizon to build a concrete garage so they were looking for short term solutions but the business case what not easy to offer it under a period three years of rent."
Collaboration and confidentiality	Metsä	"if you want to cooperate you get much more technical input and people who want to develop something otherwise what you get is that an architect is coming and we gave them really a lot of information; drawings, sketches, technical calculations and they said

		thank you, used it and it is on the market and the input/work that we did or our partners it does not count anymore. It is only about the price. And that kind of companies who think about changing it in the beginning are in the end mostly too expensive…so we are a bit more careful with giving and investing quite a lot."
X-Decks	RHDHV	"[X-Decks is] easy to assemble but it was not that easy to get it for a short-term period. We saw that many more clients would like to have a flexible parking solution. They have the demand but not really have the horizon to build a concrete garage so they were looking for short term solutions but **the business case was not really easy to get it under a period of three years of rent**"
	TBI	"And when you say [X-Decks] will remain my ownership like the construction and the floors **then this hinders our processes.**"

Table 8. Interview findings Frictions

Blockchain

The following findings are all blockchain related. Firstly conceptions and expectations towards blockchain technology are listed, followed by misconceptions. Below, in Table 11 needs of the stakeholders related to blockchain technology are presented followed by limitations in Table 12. In the end Table 13 shows possible bockchain enabled opportunities and Table 14 how middlemen are potentially affected.

Topic	Interviewee	Conceptions / Expectations
Collaboration	RHDHV OMU	"That is the real thing about blockchain; that there is not just one single party controlling. Together they control."
Immutability	C-Creators	"There is this unalienable aspect of this technology that requires a collective agreement – that is very appealing."
User Interface & User Experience		"Probably not user friendly"
X-Decks on the blockchain		"I think it is a good solution for what it wants to achieve in the X-Deckes project"
Novelty	OMU	It is the first time blockchain is brought to the table
Bitcoin	Metsä	"I just have just heard about it [Blockchain] in connection with Bitcoin"
Adaption	TBI	"Internet of Things it is already becoming normal but not so much with blockchain yet. I am still very curious because blockchain is in my first opinion is not very valuable to us"

Table 9. Interview findings Conceptions

Topic	Interviewee	Misconception
Centralization/ Automatization	RHDHV	"I think you always need a coordinating party – I think it is an illusion that the coordinating party in the middle can be replaced. It can be made easier or more automated."

Transparency	C-Creators	"for cases where transparency is the most important thing, blockchain is a very good solution"
Saleability		"it still requires a lot of energy to do the calculations, spread all the information" on a blockchain
Long term commitment	OMU	"The biggest threat is the long term perspective. A long term engagement of more than 5 years will be very difficult! That is the biggest threat for OMU in the blockchain."

Table 10. Interview findings Misconceptions

Topic	Interviewee	Needs
Need for trust and transparency	*RHDHV Metsä Delta C-Creators*	Trust, in-transparency and mutability of data are causing various frictions in the building industry - blockchain technology with an increased "trust in the system" catches here a lot of attention
Immutability	Delta	"Wheatear a company becomes bankrupt 12 years from now, that gives insecurity to people who find it hard deal with a new system."
Efficiency	TBI	"If the collaborative model can automatize processes with smart contracts, higher reliability…then it might be better otherwise if the price is not better than in the classical model it is still the best we can think of."
Reduce risk budget	OMU	"This it might be interesting for us because then we could make sure that our relevant risks could be better and easier analysed than it is the case right now"
Align silos within the company	TBI	"All the main contractors have this, all kind of different parties in-house. These parties would like to work together, they are family, but they have a different business models. If you can make them understand each other, then you can use incentives…"
	TBI	"In every project there is a different team so you have to understand what their goals are. If you can make that transparent then you can reduce the failure costs."
Interoperability	Delta	Connections to BIM and Madaster would be very helpful as a data input for a blockchain. **"**blockchain, a way to combine datasets that they become immutable and that they have a common core language to rely on.**"**
	TBI	"If you can make [different business models within the company] visible and transparent in the blockchain then you can create a common incentive. Then we as TBI can offer more insights to the developer. Then the blockchain that is available and transparent for everybody. If you can make it work in that direction it is interesting for me."

Table 11. Interview findings Needs

Topic	Interviewee	Limitations
Stakeholder complexity	Delta	"With X-Decks it is easy with 4-5players. More complex projects will require a developer again…"
	TBI	"Yes with the parking space this might work but for an office building in Zuidas I cannot

		imagine that. To create ab overseeabale system with lower investment costs."
Transparency vs scarcity	Delta	How to enhance cooperation and transparency while ensuring control over scarce information that gives power to businesses?
Risk distribution		The question is; how is this risk management distributed in the new model?
Saleability		"I think you are right in assuming the fact that the blockchain will increase in size. But I am not sure to which extend this can be fully done."

Table 12. Interview findings Risks

Topic	Interviewee	Opportunities
Interoperability	C-Creators	Blockchain as a "value chain management optimization to create transparency on the entire value chain with all the stakeholders involved"
Building passport	Delta	Understand the risk profile of anything that goes into a building and how it will retain its residual value over the course of time.
Reduce risk budget	Delta / TBI	If the risk budget can be reduced through a more efficient system then higher profit margins or better building quality can be reached.
Automatisation of repetitive processes	RHDHV	When the project volume of Park4All is rising it will be desirable to digitalize and automate the assets flows to control which materials are used or stored where and to get access to contractual relations in specific locations.
Moving from paper-based to digital	RHDHV	"It would be nice to translate working hours, materials and money into virtual shares"
Business Innovation	OMU	Blockchain seems to be a good way to formalize the ambition of RHDHV to move from hourly paid services to a more trusted advisor who distributes the risks between the parties in the chain and takes out the hierarchy.
Organigram on the blockchain	TBI	"The model in my opinion is the contract. And there is a combination of contracts. So one project has a combination of 10, 20, 30 contracts which make it the model. So if you say we make it different with one contract for all parties at this moment in time – that can be a different model."

Table 13. Interview findings Opportunities

Topic	Interviewee	Replacement of middlemen (Opportunities and Needs)
New role of banks	RHDHV	"So if we want to do it in a new way, a new role for a bank is to be the financial engine behind the system. But you do not really need a bank anymore but a financier."
Replacing big parties with "capacity"		"You can also look at an ecosystem to have capacity or capacity as a middlemen instead of a system."

Replacement of middlemen		"The contractor and developer have to be cut out. They want to hold back these kind of systems. Today the developer and contractor are the powerful parties. They understand that their role will be less important when we work like suggested"
New role of contractor		The contractor might be turned into an assembly operator, coordinating interfaces and logistics
Replacement of middlemen		Lawyers and notaries are currently needed to monitor the whole system of contracts. Blockchain technology can enable more consistency and transparency how things are working in the rest of the chain.
Risk distribution	Delta	"You would not require a developer in the first place, even in the existing system if it were not for the trust issue"

Table 14. Interview findings Replacement of middlemen

Appendix 6 - Interview Transcripts

Transcription Interview #1_ John Kraus (RHDHV)

---------- (start of interview) ----------

I: How were you contracted and paid on the last three projects you worked on?

J: We started to commercialize parking spaces as service by leasing it in the Netherlands. Somebody is interested to invest in it like a pension fund, and they pay every month per parking space a certain amount of money. That was one of the proposals we made. One of the last projects is done this way. Most of the time the client is not willing to lease or hire parking spaces. When you talk about buildings it is very common that parties want to own them. Sharing and leasing for real estate is rather new. In the last three projects the deal was that we design and sell the solution and we guarantee that we buy it back in five or ten years for a fixed amount of money. The mindset to lease real estate is often not there. Many parties lease their office space but for parking space it is rather new.

The last three projects; Purmerend, Eindhoven and the Secoya Campus in Utrecht we sell and guarantee after 5 years that we buy it back. So there is no need to finance the project itself. The financing is done by the costumer. We have an external finance, a private pension fund from an entrepreneur and he said; I will invest about 15 million Euro but we did not need it yet. We think it is a better business model if we can do it the way we proposed; to lease it and have it in our own hands – the financing, designing, erection and operation.

And because we sell it sometimes we maintain it too. In Pumerend we maintain it too. But if you sell it you have less grip on it! Perhaps in the future it will change, and it is changing already.

I: What kind of information and assets were stored, monitored and transferred, and which technologies were used to do so? (especially paper bases ones)

J: All the information we store is financial, in Excel. It is only accessible by us. But we are trying move these financial information to a cloud. Physical assets are stored at the contractor, this is not monitored. Contracts are just by email and paper-based.

The Park4All project is not scaled up yet. Three projects are done, one is in the making, three to four are in the pipeline. So it is not that big yet. So the need for monitoring your assets, especially your physical assets is not really necessary at the moment. It is different when it will scale up. When there will be five clients and five different solutions to be build and transferred – the need for better monitoring and technology will be necessary. But also when the business model changes towards X-Decks, stakeholders like Philips will be interested to cooperate digitally from the beginning.

I: Which partners were important for the business model?

J: We have the idea, we have the concept and can make the design that is all in our company. Then you have to procure the materials, erect the building, maintain the building and that are doing our partners. We also cooperate with a contractor as a separate trading partner. For our business model it is also important who is producing it, what kind of guarantees, maybe not directly for our business but e.g. for our image because the partners can 'make or break' our image and the brand value connect to the projects. And it is also a weakness. You have dependency on certain partners but you

are not in the lead for these partners. And that is why I went to Germany. Because I am responsible and it is my image and my brand and I want to be sure that that product is okay! Sometimes we have problems in our other projects and we have one contract partner. The worst we can do is to say that 'I have other partners' and you have e.g. a problem with the facade. Okay here is my guy form the facade and you speak to him. And then you say no - I have never worked with them! You (contractor) are my partner. I want to deal with you and you have to deal with your subcontractors! That means that we are also responsible for the end product – and I do not want to be in the discussion that someone of my clients says to me your product is not good and I say; 'I don't know'. That happens a lot in the building industry.

I: Were there any blockchain related projects at your company? If no: What do you know about blockchain technology? Did you heard about any applications (in building industry)?

J: I have heard of it and that is all. And I know that in the normal way we work with contracts and some contracts are put further back to other parties and that is not visible for us. So we need lawyers and notary to monitor the whole system of contracts. What I understood from blockchain so far that it can be really a chain of small parts and theses parts will be checked in the blockchain system, so you have much more consistency how things are working in the rest of the chain. The information builds up on each other. And that is really what we are trying to do manually but really never worked. Information was left out, sometimes by purpose. Fraud is really easy.

About building specific blockchain applications I have never heard also not within RHDHV.

I: Did you ever got the chance to invest materials or working hours to hold shares of a building project?

J: I think that is what we like to do. We have a couple of companies to develop X-Decks. They put materials and hours in it. And the amount of investment that is put in will be translated to shares. That is what we try to do. But all the companies that we worked with, also big ones said; it is not our competence, the only one that really liked. But then the question is how much share will I have beforehand? But we had to start the development. So I said; I do not know. It was not foreseeable yet. Or we had to take the risks of guaranteeing shares upfront. So what would be nice, is to develop together. To put in work, money or material and to have it translated to virtual shares. That would be nice! And then afterwards you can make real shares. To get a part of the benefit of the joint venture.

It is another way to ensuring profits from your investments. Normally you invest in a fund or in real estate. You can look at the changes of prices and then you sell to get profit.

We have our current processes with ups downs and I am interested how blockchain can improve that towards less frictions and fraud. Because fraud is very big in the building industry. So when it helps to avoid this kind of problems I would be very interested.

➔ Presentation

J: The contractor and developer have to be cut out. They want to hold back these kind of systems. Today the developer and contractor are the powerful parties. They understand that their role will be less important when we work like suggested in the presentation. I see the same at Park4All. For historical reasons we have a separate entity to build our solution. What we see is that they work exactly as developer and contractor. So it is our idea and business and we are fully depending on them for the subcontractors. And that is why in X-Decks we try to avoid these roles.

The real problem is: Someone wants a building, to invest in or to use…whatever. And he/she is looking for one big financially powerful party who can say; we can realize that building for you for this amount of money. No one who wants to buy a building accepts that he has e.g. five parties who will together develop and build. Who is responsible? All clients for real estate want to have one company, preferably a big one, financially sound, who says we are doing it for you for this amount of money and this brings the hierarchy. So if we want to do it in a new way, a new role for a bank is to be the financial engine behind the system. But you do not really need bank anymore but a financier.

All the subcontractors say; I guarantee money and quality for my little part. Back when I started working developers did not exist. If somebody wanted a building there was the contractor. Maybe a design was made upfront. But afterwards is was told to the contractor which building shall be build – what does it cost? But the contractor was limited. So there was also the need for a bank. So then then the user of the real estate searched for a bank to finance and a contractor to build. The developers merged that. The big developers even say the bank is below me. The client really has one contract with the developer and the developer takes care of the contractor and the bank. So can we replace them by working in another way together? This is the question. Because currently they take all the risk and profit. So it is not distributed to the parties who really create the building.

Big building companies say they do want a developer, we develop ourselves. Like BAM or Hijmans. So the bank is below them

2nd scenario: That is the real thing about blockchain; that there is not just one single party controlling. Together they control.

3rd scenario: So if there are 50 private persons who want to have parking garage together and they pay a subscription fee then it can be enough for us to initiate a X-Decks project.

The dilemma of cooperating with classical developers in the case of X-Decks is that they say we want it – how much does it cost? We say no – what does it deliver? And they say that is not your business – I want your product as cheap as possible. So it is not about sharing.

In our case all the parties collect the materials themselves at the end of the lifecycle and reuse them.

The building passport, especially for the technical information is very important. If you do not have the building passport it is impossible to do what we want to do. The financial model and technical documentation have to work simultaneity.

---------- (end of interview) ----------

Transcription Interview #2_ Wouter van Twillert (Advisor)

---------- (start of interview) ----------

I: Are there any blockchain related projects at your company (C-Creators)?

W: Not so much. What I think is very interesting about blockchain in the circular economy, is about creating transparency in the complete value chain. It could be very interesting if you could use blockchain technology to set up a value chain management optimization to create transparency on the entire value chain with all the stakeholders involved. As far as I know this is not existing yet but I think it is really interesting.

I: Many companies are experimenting with blockchain technology within their protected environment but there are no best use cases yet…

No I also have not heard about them. This is also why I would like to meet you because perhaps you can tell me some inspiring examples.

I: (my interview is more related to the building industry/X-Decks project but we can go beyond that later)

I: What do you know about blockchain technology?

W: I think I know just as much as most people. It is about creating a shared ledger where everybody can see all the data that is entered by one of the stakeholders and implemented into all the other locations. Could be very useful for paper based transactions where people cannot cheat the system anymore. So everything is transparent. And I know more or less how the technology works and I know we are in the early stages of the Hypecycle, I think the hype is still going to continue but it will also go to the dissolution phase and one of the reasons why it will go through this phase is because it still requires a lot of energy to do the calculations, spread all the information and also it will have an impact on performance because you need to update so many systems at the same time - it is a prone issue.

And I think that blockchain technology sounds like a silver bullet for many people, but the market still needs to determine what the best problem is that blockchain is a solution for. So for cases where transparency is the most important thing, blockchain is a very good solution. But for all other things where blockchain is mentioned, I am not sure.

I: Did you heard about any blockchain enhanced concepts in the building industry?

W: I do not know if you heard about the paper use initiative of the Rabobank? What they do is a pilot where they have a system for your household and when you use your washing machine then it is automatically deducted or added to your bill every time you use it. So it is real paper use case and they use blockchain technology to do this. So they have an interface with an electricity company to pay for the electricity, they have a set up for some kind of things. It might be interesting to look into.

I: One key concept of the X-Decks project is to hold shares of the building (you are not really rooted within the X-Decks business cosmos)

W: I am one of the persons who came up with the X-Decks idea.

I: Nice. Did you ever got the chance to invest materials or working hours to hold shares of a building project – like intended for the X-Decks project?

W: We invested working hours – we did not discuss if that would be transferred into shares

I: So the idea was there but not set into practice yet?

W: Not as far as I now

➔ Presentation

I: What do you think about the suggested processes?

W: It seems to be a good idea to create trust but like I said before I am not quite sure if blockchain is the only way you can achieve this. Because I also think that if you set up agreements with each other, within the ecosystem that you collaborate, it should be also possible to do similar things. And the only thing that changes is that instead of one party is responsible to create the ecosystem and doing the administration, that is put in the middle, also one organization has to set up this first initiative so it is always a party that takes the initiative and the others sort of have to trust this party that they do it in a correct manner. But I think it could work but I am always a bit critical about blockchain…so many people talk about blockchain that it is also put into situation where you can come up with other solutions. This is also what I recommend to you; Find a scenario which is not blockchain based and see how it works compared the ones you showed. I think this a very interesting topic to investigate. Because otherwise you are getting so much focused on putting blockchain inside that you lose the bigger picture. Because the actual aim is that people collaborate. Because for the shares you do not need blockchain.

And also thinking about contracts you put in 1000kg of steel and you get 25% of all the earnings and you put in 3h and you get only one percent. It is just a simple contract/agreement.

I: (The point is here is scalability so if you think just about a core consortium of five parties then it is possible without blockchain but when you broaden the network and set standards to join this network and automate transactions then it would make sense otherwise the system is too easy to manipulate)

W: But the fact that it is easy to manipulate does not mean that it is going to happen. Because there are a lot of collaborations at this moment and they do not use blockchain. I would find it very interesting as a university to see the differences of achieving the same result, one with blockchain and one with the means that are currently in place. Basically just contracts between two parties or one organization coordinating this collaboration, because it is already taking place. So I think blockchain could very well help to find a solution but it is not the only way.

I: (One thing that distributed databases cannot provide is that every party in the system has equal read and write permissions)

I: What kind of other barriers or roadblocks do you imagine in the blockchain space?

W: That people do not know the technology yet. Or that the performance of the system becomes slow. Like with any new technology I guess. So that it promises too much of what it can do and it does not meet up to the expectations.

But it sounds like a good plan. So it could work

I: Do you see any other opportunities that can profit from blockchain technology?

W: I think it is a good solution for what it wants to achieve in the X-Deckes project. I think it is a very interesting concept to cut out the developer. But what I am not so sure about if the developer is always untrusted by their subcontractor.

I: (it is not about that they are not trusted but that they do not show their profit margin)

W: I know that is the case but it is also possible to solve this in another manner to have another kind of relationship between contractor and subcontractor. That you share e.g. how much money you get and that you move it more into sort of a partnership between the contractor and subcontractor.

I: Can you name any examples?

W: Yes I think a lot of organizations they co-create and do something new e.g. Nestle with Philps, Krups, Siemens… to create the Nespresso machine. This was a co creation.

I: Are there also examples you know from the building industry?

I am sure there are also some in the building industry. It happens a lot with innovation these days that you do not subcontract innovation but that you embark on a joint venture and you co-create a new solution. But I also think that it is something difficult but blockchain is something that could help to set up trust into the relationship. It is not the only solution that is what I am saying.

And from an IT point of view blockchain might be very interesting, so people who have a technical background they are getting easily very excited about it and it is always good to have other perspectives in mind. The user perspective for example. I might not be very user friendly, yet.

I: Do you have any additional comments, something that have been missed or additional remarks?

W: Like I said it is good to create a couple of scenarios and see how you could achieve a similar thing without blockchain technology, hopefully that is the best solution, because for a number of reasons it would be very interesting to see the comparison.

---------- (end of interview) ----------

Transcription Interview #3_ Olaf Blaauw (Developer)

---------- (Start of interview) ----------

I: In the context of this interview and the X-Decks project I consider you in role the developer…

O: Yes, I work as a developer on cradle to cradle inspired buildings, looking at area management rather than just building management, to create wise areas rather than smart buildings.

In Hoofddorp we were trying to put together an ecosystem with companies and thinkers and finance people to go for a collaborative design within their systems to create new ways of doing business, exploiting residual value and exploiting residual functional value, not so much material value as in means to finance upfront investments. So you get to total costs use based exploitation systems for houses or products or whatever.

I: What was the main problem or need that is covered by your company's product or service (for the X-Decks project)?

O: The main issue with any type of circular business development, be that project development, a simple product or whatever, is that there is always a split incentive that might occur in two ways, these are the main two interesting points that you need to solve first. Firstly, if the investor or developer invests a large sum of money in making something more durable or more circular, the only thing that the long term investors like pension funds, who takes over ownership, look at only at the exploitation that comes from rent and a necessity to have a low baseline of fixed costs. So the return on investment which comes at the composition of the building at the end of its use, the residual value which is then taken out of it, is never taken into account when we look at our upfront investment. So project developers will try to develop something for the least possible amount of money and sell it off for the highest price. Because it is the **highest risk of the entire process** actually building it and putting it up, somebody else may make a lot of money utilizing the building so this high risk level is also transferred to the fact that you have a very **short horizon, 2-3 years** at most between starting development and selling it off to a long term investor. So you are taking care of the financing of the building process, you take a return on investment on the financing process not of the actual object - this is where it goes wrong! Because now out of the sudden there are two incentives at stake here; One is the short term; let us get this project going for the least amount of money available, yet make as much out of it as we can. On the other hand if you build a residual value then you have that residual value coming out of your product or house or building at the end of its use cycle but this money is not being utilized, to take off from the upfront investment. So **you do not have total cost of use based finance system** maybe you get some "Gefundenes Fressen" at the end of the line when you have done it right. And if that are not just two different parties but two different moments in time like 30, 40 or 70 years apart then there is no real incentive. That is the main problem. Because the technological solutions are easy – you can build something that is totally circular which retains maximal functional value, which has enclosed loop systems for electricity, water, whatever…but **we will not pay for it because although this pays itself through a lower total cost of use, because of the investment structures we take, we do not do it!** So the main snag is not that, but the fact that the financing underlying it is not properly done.

The other thing which relates to your topic, is that we do not understand the risk profile of anything that goes into a building and how it will retain its residual value over the course of time.

I: Do you think that these short term investment periods (like in the case of X-Decks) make it easier to change the system than with long term real estate?

O: Yes anything that can be arranged from 3-15years is doable in today's climate. So a car, refrigerator, cooking appliances…not, what relies on gas – we know that there is a disruption coming up in 15years from now, there will be no gas. So it is sustainable obsolescence which takes some part but also just how do we take value at the end of use or do we have current assets that will leverage. The point that I am trying to get to that the perceived risk of having a return on investment which might be different from how we envision it today because you do not know the actual development of value of a certain inbuilt objects or in a car or refrigerator, and it will evolve over time. It relies therefore heavily on the quality of the information you have – and this is where blockchain comes in. If we allow information on any element of a building or a computer, if we allow that to be in a database which might exist or not exist depending on someone pulls the plug or not, or **wheatear a company becomes bankrupt 12 years from now, that gives insecurity to people who find it hard deal with a new system**. Now introducing blockchain or blockchain type technologies where you get unalienable data this helps. This is where the connection is between, how this technology supports the financing, which is the main issue, this is where it becomes interesting. If unalienable information allows you to have a better perspective or projected return on investment, let us say in 10 or 15 years because you know at least the information that will be available then is the exact same information you put in today, then you start dealing with less insecurity.

I: Before we move to blockchain I first want to talk about your relationship to the closest parties working the developer…

O: Also conservatism is a main blockade. 'This is how we always have done it. Why should we change – it is working fine. There is no scarcity in the build environment. There is enough steel and concrete – what are you worried about? – there is not enough copper – Oh we will deal with it when we get there…No had to deal with it 20years ago! Sorry, it is not five minutes to midnight it is 3.40am in the morning. You know we live in 1.8 earths. But the conservatism is another big stumbling block so mindset.

As Isaac Asimov said 'The saddest aspect of live is right now is that science develops knowledge much faster than society gathers wisdom' that is how it goes.

I: Looking at your role as a developer, do you see yourself located between the investor and the contractor? And how were you contracted and paid – can you describe the process looking back at the last three projects you have worked on /the last three contracts that you signed with contractor/investor?

O: There is a group of projects called Park 20|20 that I have been prevailed to. The main thing there was; we truly wanted to build it in a new way, cradle to cradle inspired, with my friend Kurt he ran into William McDonough at some stage and he was inspired by the way of thinking how nature does everything in a circular fashion and does not produce any toxins except needed for defense. So if you could do a building as a material bank, how would that work in the light of scarcity? So there the role was to find contractors who would allow us to access their supply chain, to their sub-contractors and their suppliers. For the simple reason that, the only way you can do this properly is if you have **collaborative design**. Because on average in a Built Environment project, the failure costs will amount up to 20%. This is because people worry more about pricing rather than about quality. So they say the specified parameters that need to be met, we need so much installation value, so much construction for this and that, the architect has to put forward the design that requires certain parameters to be met, so you get to tick boxes. And the only thing that contractors do is basically churning the last cent out of their supply chain and sub-contractors. So what was decided was not to say that 'Give me the lowest price for this state of quality.' Because you will just mention certain aspects. So people are racing for the bottom of quality where they barely meet the requirements but

the lowest possible price level. And this leads to a bad product. So we change it around. We say, we do not want you to give us the lowest price but this is the fixed budget that we have ready to build this building and this is the price we can sell it off to an investor, with a decent margin for all, including yourself.

So who can give me the highest amount of quality for this money? Rather than race to the bottom, you race to the top. So can I still get a sufficient margin if I get this really good stuff? And you see this is actually a better solution than all the others in the market but it will cost you more. Then there is a business case to be made that it will also pay itself, let us say less costs of maintenance due to the higher value goods. So e.g. the elevators we came to an agreement with Mitsubishi, who make the best quality elevators from my point of view, but they are a lot higher in the upfront investment. But if you consider the total costs of use and ownership. They have a point of return let's say seven years in the future, where they are actually cheaper and they have more residual value. So you have less costs at the end of use as well because you retain more functional value inside of it. So we actually use that to say we can have a fever service. So we do not buy elevators, but we buy vertical transportation and the amount of movement and the amount of use we brought in a fever service contract

The investor was okay with that because they tend to look at how much money do we make out of the rent over the next 15years. So they are less interested in that. The developer was even interested in making this work the proper way. Also the renters were willing to pay more for the higher quality. This is the whole story if you have a higher quality working environment, this is an office building, you have more productivity, less sick leave days. It pays for itself quite easily, it is a much healthier environment. Because we use plants rather than air-condition to clean up the air or to filter the dust particles. But going back to the process, we said to the contractors we want to have access to your sub-contractors to come up with collaborative design so that we do not end up with a 3.5mm board and a 4mm frame that requires half a mm of rubber that needs to be inserted on the spot or have this panels taken out and new ones brought in which costs us all this percentages of failure costs. We want to reduce these failure costs. So practically we aim for 7-8% to have 12% of margin to be distributed among all those player who make this possible. Now for the contractor we simply said that, how much margin do you intend to make with this project? If you do not allow us access. Because he said you will not get access to my supply chain. We said, we want to work with them and we want to work transparently with them so that means you have to step out of the way, remain part of the process, but allow us to start working as a community in practice.

I: Was the contractor willing to step out of the way?

O: Well we said this is how much we want to make and this is how much we think that you are making. The contractor want to have 2% margin on this one, this is normal in this market, this is 2010 so at the height of the crisis. We said well we offer you 3%. That means a 50% increase in profitability. Will you allow us then access? They said that is that case okay, because they knew their margin was save and then they sort of dropped their guardiancy, they said you get access. So you got access to about 47 companies the whole subcontractors, manufactures etc. and we put them together in a pool and say we collectively design this building. Because everything is connected. The system is like a body were, what flows here ends up there…if we want construction to be better designed for this assembly, we do not need any wells or poors anywhere. We need ground joints. We want to understand everyone that this is the case. So if two materials meet where two different manufactures or suppliers are paid, they need to understand that their interface is not through contractor, who pulls all their things, but they are literally, as they are connected to the building, they should be connected to the business and to the design process. Now this is for change

I: Did the subcontractors and manufactures accepted this challenge?

O: Not all were able to do so. But the ones who were, were selected. Not just for the quality of work but also for the quality of collaboration.

I: Did you also open up the profit margins for the subcontractors?

O: Yes, it is about transparency. In any business it is about trust. You need to trust each other completely. I have no idea why I would bother sending out different messages than the ones that I am actually thinking of. Otherwise it only messes stuff up.

I: This is blocking currently a lot of innovation.

O: People are worrying to much about internal processes. They are locked into this idea that you need to keep your knowledge to be unique so that only you make profit from it. Elon Musk said; He is on a boat that is leaking and he got the best possible bucket design available, so he would be fool not to share the design with other ship makers. This is why he shares his patents. On the other hand what he does not say is that, what is equally important; if your technology becomes the mainstay then all rules and regulations that come from governments will be based on your technology. So it will not have to be facing a lookout stage in the future, just because you were uniquely doing your own thing.

I: Are there any other projects besides the Park 20|20 that you can describe your business processes?

O: I never been involved in classical project development and I do not want to get into it. There is a project that I am looking into right now, that involves 300 apartments in Shalun Green Energy Campus in Tawain. It is done with Taiwan Sugar Corporation.

There are also 229 apartments being put up in Hoofddorp. It is done with Delta Development Group. In both processes I am looking into how to make the projects circular in nature. Again, **finance is the main stumbling block**. In one case we are looking into minimizing the amount of time that can be spend on the building itself, by building and constructing it offsite in a modular fashion and also pushing developments like 'kitchen as a service' all kind of things as a service. So we can say we have 100 apartments taking SieMatic kitchens. I think you can make here a proper business case that allows you to make more money out of the use of these kitchens then if you sell them and at the same time because you are selling less for the price that you are asking you retain ownership of those elements. So for recycling and refurbishment process this would be totally acceptable. At the same time you allow for a lower price per unit to have a kitchen at your disposal.

I: The investor might agree but does the contractor agrees to lease their products?

O: At the Hoofddorp project we are really looking for somebody specialized in offsite construction, it is called 'unitized'. So the key is **flexibility**. The nature of the apartments might change over the course of time. You need to be able to do changes to the interior based on future requirements. Modular systems work here better than any fixed solution. So it is not just about looking into circularity, modular design, for the sake of flexibility but to increase the value of the property. So it is a more interesting investment to do because it allows greater flexibility in the future so the ability to make money off at some stage while minimizing the costs involved to make those changes that are required. So you are working at different aspects in different projects that are highlighted so that your current project will be the worst one as of them because the following project should be better.

I: What kind of information and assets were stored, monitored and transferred, and which technologies were used to do so?

O: The main source is BIM. Where everything that goes into the building is being digitally represented. So there is a 3D edition of the building with everything in there with an ID attached to everything. You know where a certain steel beam is, how much steel there is. The only thing that is not really done, because the technology is lacking, is a real time management tool. What should happen is that the information that gets into a model should be readable as a spreadsheet. Then you can use it for asset management, so that you have constant access to what is in there and everything that changes. So that if there is a fire or somewhere is a new layer of paint, that is better quality than the prior layer then that has an influence on the **residual value**. You should be able to do that more properly. **Now it is a one-off thing.** It goes into the model and it is available to all those who need it. But it should not just be a document that comes into existence at the start of building but maintained until you demolish it or take it apart. And if you have unalienable information and not relying on one database of input from one organization then goes bankrupt in five years and the building gets taken apart in 15years, then where is the BIM?

I: There has to be some incentive to maintain this model…

O: And to adapt it over the course of time. And also every time the building is cleaned. You should know it has been cleaned. So when the cleaner enters the room, it should be registered. You get massive data. Okay it might not be to that level of detail but things should be automatically done. So if something gets taken out of the building then you need identifiers attached to that element to automatically go into the database. 'No longer present as of 12/06/17…'

I: Which party do you see responsible to collect and maintain these information?

O: Eventually the investor. As they are responsible in maintaining the value of the building.

I: Did you ever suggested that?

O: Right now they are still listing to it as if it is science fiction. But it is like that you take two steps up and one and half back and you go up again. There is since 2016 a definite change. We see for instance that the Dutch standard institution (NEN) is now adopting a program to create standards for circularity. Which revolve around having reliable data at your disposal over the course of time. And there is Madaster. Which is an initiative that creates a database that tells you where everything is, material wise in the build environment in the Netherlands. Like a Kadaster which shows where buildings are, Madaster shows where materials are. These are relatively crude measures – they need to be refined. So one of the things that I have been doing is to put together a program for the build environment for the metropolitan region of Amsterdam where we start harmonizing those different elements. Where it also comes to the blockchain, a way to combine datasets that they become immutable and that they have a common core language to rely on.

It is easy to fill out a form or click somewhere on a screen on an interface. Here you introduce human error. I do not say that human error is such a big thing but if you could decrease it from 2% to 0.5% that actually helps a lot already. There is also this rule of diminishing returns. If you can really get this fine mesh when, where what happened, information technology gathering. It comes at a price. And the IoT sounds like a great idea. But how deep does the factor has to go to before we end up at a point where it is no longer useful to have no further hyper resolution.

I: Which partner are important for you as developer?

O: The municipality of Haarlemmermeer was quite flexible in allowing things running differently than it is normally the case because there is a very fixed set of things that you have to do before you can put a building anywhere. And the ability to experiment, not just with the financiers but also with those who create the space in which the project happens. So if you have an enthusiastic alderman in

the city council then he or she will provide the space where this can flourish. So that was the case, and alderman could convince the council to do something completely different and put Hoofddorp on the map and there was a financier, in this case Delta Development. We said who is willing to put in the money because it looks like a sound investment. Because we still classically build around transferring ownership to a long term investor later and it worked. The people were getting enthusiastic. We started in 2010, and there is no empty space, successful operating companies, successful operating buildings that collectively teach us a lot how we should never look at things in isolation. But e.g. how the entire water management for the area look like, how do the buildings respond to each other, how are the public parts created.

The design plan for this autarky area, so energy neutral, so PV is essential. PV is probably the smartest way to have renewable energy at your disposal. The zoning plan would not allow an angle of your rooftop exceeding 18degrees. For PV systems you need an angle between 30-60 degrees. Otherwise you do not make maximum use of the possible kw/h per day. The council or municipality created then a plan that is free of these rule. So you can experiment with new things. But these are not just physical rules but also financial ones. So you need the ability from the municipality, country…whoever owns the zone that needs to be developed to open up for experimentation. So then it facilitated the ability of financiers, constructors, companies that wish to settle there,

I: …so that the rules are defined during the actual design process. Was the municipality leasing the land?

O: They are willing to lease it but in this case they sold it. Because it was a classical financing situation. For instance the SADC owned the Schiphol trade park. Here SADC owns the land which is basically co-owned Haarlemmeer, Schiphol airport, City of Amsterdam and Province of North Holland. It is like a communal area that is bought to provide Schiphol Airport with growth opportunities, through real real estate development. There leasing is considered. There is even an area where we are putting a tiny houses project and that shall basically become nature because it cannot be used for other purposes but tiny houses actually help to create nature around them. So if you are flexible with the rules we can start planting trees in a way that is also functional on many levels and gives us the possibility to experiment novel ways of utilizing public space. Without sacrificing the main intent which is can we get biodiversity here. This creates a nicer thing than just a row of shrubs or just wild flowers growing. It is also about aesthetics and ethics maybe but there you have a situation where it is important to think about what do we want to achieve, not what was it that we thought we would be achieving ten years ago, that let to rules and regulations that with the current mindset do not make sense anymore.

Blockchain

I: Are you involved in any blockchain related projects?

O: No. Just privately I am interested in Bitcoin.

I: What do you know about blockchain technology?

O: I know the basic principles. The chain shares information, any change of information becomes impossible to do unless it is verified by the network. It is like a peer review in electronics. That is what appeals to me. I never been into coding, I am not an IT expert but I can understand its maintenance, its design to some extent. It sounds appealing because of its inherent reliability. What starts as a Peer to Peer network, then becomes a peer-to-peer information checkpoint. So the interface is similar between all of these blocks in the chain, and if they start to be not similar then they are simply not acceptable. So there is this unalienable aspect of this technology that requires a collective agreement – that is very appealing.

It is also one of the main reasons why Wikipedia works. For things most people know about. You will find lots of niche topics that are totally bogus because there was not sufficient peer review put on that bit of information. But once the information is shared by a sufficient number of editors then it starts to become the weight average of what we think about a certain topic.

And people would think that would not work in practice but it is like asking 500 people about the amount of marbles in glass – they will all give different approximations but the weighted average mean, the result will be affrightedly close to the actual number of marbles in the bowl. So collective intelligence works that way. That is the interesting bit.

I: Did you heard about any blockchain application in the building industry?

O: There is an asset management tool by ABN Ambro. That is an internal tool. It is also one of the things I would like to introduce to the people of Madaster, people working at building material banks and the people that work on a new version of BIM that is where integration needs to happen. For me taking the Torch project from ABN Ambro not just as an asset management tool but also how the assets themselves, to take extra depth of information that is in the buildings themselves, not defining the elements of buildings, but defining the elements themselves. Because then the financial drivers that are important are increasingly designed into the system and that is where it becomes interesting. It is taken into account you need to know certain things to larger extend than others and changes to the system that have influence on the finance as well as on the construction.

Torch is just looking at the finances; What do we own, What is its value? &How do we make sure that we understand this in 10 or 20 years down the line? But is a start. But the blockchain technology that underlines it is sufficiently interesting for me to see if they can expand that in the way we look into buildings themselves and their asset values and how they transform over time. To have the least widening bandwidth of potential residual value available to us so that we can make predications over 10, 15 or 20 years.

Besides that I have not seen any realistic blockchain based model for the work I am trying to do at the moment. So I have to invent it myself. With the help of some brilliant blockchain coders.

➔ **Presentation**

@Traditional/Shared ledger diagram. **O:** I can fully agree to the current ledger situation. If information is not shared then by definition it will divert over time! By definition! Even if you try that it not happens. Information gets lost, misinterpreted.

@Hierarchical organigram(lower parties). **O:** This is how we put the project together, based on also the lessons learned in Park 20|20. You need the community of practice who actually does it and not just the people who get paid to make these people work. So with X-Decks it is actually almost like taking out the middlemen. Unless X-Decks itself is the middlemen. Which retains ownership of X-Decks and puts them where they are being exploited on a case by case people service based model.

@From hierarchical to decentralized model. **O:** This is not shown here; the developer takes the risks that the investor is not willing to take. The question in this new diagram is; how is this risk management distributed in the new model? From a technological point of view this works, but you would not require a developer in the first place, even in the existing system if it were not for the trust issue. (how much of theses risk is the consortium / RHDHV willing to take?)

This is what we were experimenting with deferred ownership putting ownership for energy to Eneco, floors with one company, furniture with another company…but then you get into a situation where take from 160 owners of parts a monthly fee. And the part in which it needs to be split over a 160 companies and some will want to change their role, change it while it occurs, the manageable aspect

there is…with X-Decks its easy with 4-5players. More complex projects will require a developer again…Most of the people that work in this area are not highly educated. These are small or medium enterprises and they just want to sell stuff. Someone found a great new thing that he import and sell and make a fortune. But these people do not think about how would be my place in the blockchain, what is my goal…no I buy stuff from China and sell it to a building project and I make money to go on holidays. That is how it works for a large part.

You always need some brainpower to integrate the effort. And the ledger itself cannot manage itself. It might get a long way but…

I: … this can be solved through finding bigger companies who can provide a majority of materials and services needed and standardize the processes and plug the smaller companies into these processes or take over their commitments.

O: It needs to be organized somehow. Being part of a developer I do not say that developers should not be necessary. Currently if it were not for Delta we would not have park 20|20. And we would not have some developments in the Netherlands when it comes to how to construct buildings in a better way. And all steps from the value set that we share that is I want to leave the world in better state than I entered it. Is the only propose in life we have. There is no other. Because if you can ease suffering or increase happiness that is a good thing. If you do not do anything about it then you might say in the light of eternity everything is trivial so why should I be bothered I take what I can get or I deliver nothing because effort is trivial then it does not matter. I think as we are here we are alive and experience life we rather be happy than unhappy. We should be living in great buildings rather than in bad buildings – very simple…but taking middlemen out is always a good idea but then somebody else needs to take over the functionality. And the system you design only takes over part of the functionality you need to be very strict about which parts you do not take in the equation and what still needs to be covered because otherwise you are just focusing on some things that a developer or contractor do, make a whole new system out of that and forget about the part that you did not look at in the first place. That is always a risk, what I try to point out.

People may wish or wish not to live in a certain building in a certain location and the fact that they once decide that they wish to then they have to concur on the conditions on which they will. For the price, quality etc. you cannot rent out something that has not been built yet. So someone takes the upfront risk that you will build a building. You see a requirement in society to have better buildings available to initiatives that are not taking place currently elsewhere so you will cannibalize peoples efforts. By creating something which adds more value to the system than the current solution does. That is called competition. Sometimes that is fine but not always. But at the end of the day somebody takes the risk of 'I will build something better, something beautiful, very functional who is filling to come and live and work there?' That is the initiative, the biggest risk, what the developer does.

I: What do you think about the suggested processes?

O: I think you are right in assuming the fact that the blockchain will increase in size. But I am not sure to which extend this can be fully done.

I: Do you see any other opportunities?

O: The main thing it is meant to do is to give certainty in risk management and risk mitigation for financial underpinnings or the exploitation for a project like X-Decks. This is covered by how the blockchain works as a digital representation of the physical reality like materials, how they went into it and how we modulate or moderate the information. That is covered. From the other point of view, making it applicable to the financial, non-physical entity. It is obviously true that if you have a

blockchain based asset information, that what you do with that asset information would probably fair well or better when it is similarly based on unalienable information. So having those two as one integral blockchain would make perfect sense to me. But that is as far as I would go. Because then you have everything at your disposal in a controllable and realistic and objective format. How open access can this be? That is where it becomes tricky. Because with blockchain you expect the information to be widely available to all, almost by definition, and at the same time financial figures are usually kept confidential. That is the question? Or where does the blockchain stops with transparency.

I: You can filter information between the parties on a blockchain…

O: But then you start to isolate datasets again. 'Only those know who have access' And here it becomes like a very extensive database. Which is not the intension. Let us put it in very practical terms. If someone needs a certain amount of steel beams of 16m length, 25y down the line and X-Decks has more decks than it is currently utilizing. How would be someone able to access some material information hub – where would they be right now? At which quality at which price? So then the blockchain needs to be transparent. But the same information is also the asset tool that the owner currently uses to establish what kind of fee for service they should be asking. So there is a conflict of interest before you know it. Between having transparency so that the system works or having a lack of transparency so that you may maintain internal processes and knowledge that you require. We do not live in a fully shared economy, we live in "siloed" economy but we will accept those silos only to certain extend. We think now the silos have become too "siloed" so we are able to apply blockchain to open up the world but we cannot open up completely because that actually that actually also means that this is for most business models this is detrimental. So that is the transformation you are looking at**, how do I allow access without people feeling to lose control over scarce information which gives them power**. So that is an interesting angle that you can also approach in your thesis. It is more on a meta level buy it is there. Because it means if you have an adopted system or non-adopted and then it is about trust.

I: Any additional comments/remarks?

O: I was part of the discussion that led to this topic, that is now turned into a proper thesis. And I am very happy to see that you added information that has been missing during prior conversations. And you also force me to think again. Which is the most powerful gift you can give to any person. So thank you for that. I am honest. You should always question your beliefs. When you are thinking about stuff is different to how it is working and then you find out in practice that it is slightly different. And I have never considered the outside ring of suppliers and secondary businesses, single individuals might have a role to play in maintaining the blockchain in way that it becomes the main sensible. And this leads to my last remark; how do we stop the things that are required for current businesses but will hinder fully accessibility – how do we make those two ends meet? How do not end up in the middle?

---------- (end of interview) ----------

Transcription Interview #4_ Sander van Schijndel (Investor)

---------- (Start of interview) ----------

I: Are you familiar with the X-Decks project?

S: More or less, we are working together and pitching it here in the city of Utrecht.

I: What was the main problem or need that is covered by your company's product or service (for the X-Decks project)?

S: The situation with OMU where I work right now is a bit different from a regular investor or developer because we are founded by the province of Utrecht to make sure that certain areas are solved; to improve the industrial use or to transform the current use to different uses. We make sure that government and private sector work together better in Utrecht. We want to reduce the number of parking space in certain redevelopment projects. We want to use mobility in a different way. But we also want to reduce the number of car parking spaces because there is less need and they (the developers/municipality) do not want to build for vacancy. It costs a lot of money especially to build parking spaces underground. So we are trying to bring those two parties (developers and municipality) by pitching the X-Decks project. So we do not need the concept ourselves we will not be building it ourselves or maintaining it ourselves. We try to propose it to the city of Utrecht.

I: So temporary parking solutions are something very much in you interest?

S: Absolutely, it is a big urban revitalization issue. Projects are often phased, in more than one phase. No one knows in the beginning how it will end. And we see a reduction the use car parking and car use. At least that is what we want. **Policy makers want that as well**. So X-Decks is here an interesting concept to help. But it is not our own problem or need, it is more a problem or **need in society**. And real estate partners are having this problem and we are trying to help to solve this.

I: Which role is OMU playing in the process between the public and private parties?

S: We work as an investor, financier or lender. It can be in any of these roles; we advise, lend and invest in properties. And it really depends on the question that is asked and the problem that is posed to us. So it can be in the hypothetical case of X-Decks. Right now we are advising and linking public and private parties together. We can also finance – so we can lend money to RHDHV possibly. We can buy or lease the land to an X-Decks project but we do not know at this moment which of these three roles we will play; if only the advisor or the financier or investor.

I: How were you contracted and paid – can you describe the process looking back at the last three projects you have worked on /the last three contracts that you signed with contractor or developer?

S: The last three project I have been working on, we solved were financing problems. A developer wanted to buy a vacant office building or disused industrial area and wanted to change the office building into a residential building and use the industrial site for a modern industrial use. They could not get the money lend – the bank said it is not interesting for us. So the last projects we worked on at OMU, it was the case that OMU lend 100% loan to value so we covered 100% the acquisition of the development so that they (the developer) could buy by the land and building, get a contractor and architect to make a plan and once they got the rezoning permission, once they had the development permission, the development application has been secured then there was another

bank that said ‘we want to finance this’ or could set it up. And then we could get our money back so that is basically what we do; we put money into projects on a short-term basis 1-3years. We charge some interest to cover our own running costs.

I: The bank stepped in in all three projects?

S: Yes a bank or an investment fund in one case the project has been sold privately , that was an apartment development, where the new apartments have been sold privately to owner occupiers.

I: What kind of information and assets were stored, monitored and transferred, and which technologies were used to do so?

S: The companies and parties that we are working small scale. We do not work with the big developers in Holland because they have their own funds, they have their own knowledge and expertise. And they do not really need our expertise or funds so we usually work with pioneers, the very first parties who come into an area and want to make a change so they have a lot of guts they have a lot of courage. But they do not have necessarily that much money or expertise. That means that those parties are not always very professional. We help them a lot so that their budgets are correct, with a cost analysis, site surveying and we do this basically with Excel. We also have a digital dropbox, to share documents but it is quite old fashioned, the way we work. Paper contracts, digital as well in the dropbox. But we do not work on plans or drawings ourselves. We do not commission architects or engineers ourselves. They are commissioned or contracted by our clients and we check if the design or plans are okay. We do not have the final responsibility. It is the clients plan and we help in making sure that the clients’ plan can be build.

I: Besides, excel sheets, paper-based contracts and dropbox are there any other technologies that you use like BIM?

S: No, one of my colleagues he comes from a real developer and was working with BIM in the past but we do not the moment. Usually our projects are not complex enough for BIM. Now and then it could be interesting but these projects are still in the pipeline. We have not worked with BIM yet.

I: Which partners are important?

S: Banks can be important as co-financiers. So we finance together. We do 50% and the bank brings in 50%. For us a very important partner is the regional government. We act as an intermediary between the government and the private sector, founded by the province. It is important for the province to make sure that we do the right thing. So in that sense we work with governments as well. And we do work ourselves with a digital map. Based on GIS and this is where we store our issues and leads of projects. And it is not for individual projects. Individual project files are paper-based or in the dropbox. We have sort of a lead pipeline that is what we use GIS for and when we have a one-to-one meetings, people want to do something, we show them a map and talk about the map together and we see where there are possibilities, issues, site and land-use restrictions. This is the digital environment we are currently operating in.

I: Do you share GIS information with other parties?

S: It could be possible. The GIS map was my idea, I am working here for 1,5 years now. Before I came here, they are very knowledgeable people, they have years of experience but they are men of a certain age and they have certain ideas about digital technologies and they are very old fashioned. I am probably the most modern of my colleagues and even I am struggling sometimes. Our company is quite basic in that sense – you can call it old school.

I: What do you know about blockchain technology?

S: What I understood is that blockchain is more and less BIM but then all the parties can make changes for themselves in plans and designs and whatever one party changes it is instantly visible to the rest.

I: …it gets updated for the rest too but they have to validate the data (explaining blockchain)

S: Our company is very small and low-key. We help others to make their plans work. Unfortunately we did not get an insight into blockchain yet. It seems to be very interesting.

I: …it still early days for blockchain

S: Yes, I know but even for BIM. I know about it from my previous job but I have not worked with it by now.

I: Did you heard about any applications (in building industry)?

S: No, not yet. I heard about blockhain here and there but it is still 'far from my bed'. It has not come close to us yet.

I: Did you ever have the chance to invest materials or working hours to hold shares of a building project?

S: No but this is something we are talking about with the 'Smart solutions' team at RHDHV. Because the X-Decks project might be interesting to get together. We have a few meetings planned for that and I am very keen about the ideas that they have, because I do not know much about it by now.

-> Presentation

S: Individual to shared ledger – we are more or less the bank in this model and we realize that we do not really have the time to dive deep into every project. But that involved risk and considering this it might be interesting for us because then we could make sure that our relevant risks could be better and easier analysed than it is the case right now.

…

Is the underlying contract between you and the steel beam manufacturer visible for all parties?

Wow, the aims I definitely share! The means as in blockchain I am not fully into it yet. It is quite complex. The principles I agree on. Basically for a party like OMU the choices we have to make are how deep we want to join into the chain. Till now we basically let other parties in chain do their thing and a certain point when the chain did not work, when the chain was stuck we helped with a financial injection or our expertise, legal 'grease'. We could help to get the chain to get back to work again. This would be our part in the chain. The whole thing about X-Decks and that is what I still need to talk about with people at RHDHV what do they require from us, how deep do they want us to join the chain?

I: To be an auditor in this process and providing land would be the main asset that you can provide in this process?

S: Probably our own land or making the money available for them to acquire other persons land and then you get the short term lease discussion. It is a different discussion but what you might now, that in Utrecht the area that we are most interested in building the X-Decks is a huge area with about 5000 new houses being proposed. It is now divided to eight or nine different land owners, the city is here quite a large owner they have a quarter to a third of the ownership. The rest are various private

parties. Some are investors some developers. OMU does not have any position here at all. So this is where it will be OMU will not buy this land and it will be up to these parties to make land available for the X-Decks to be built for the first three years or two years. And then once it is developed they might change the location. And this might be how the X-Decks project migrated through the area within 10-15years. What my role will be in here, I am not sure. It might be just greasing this quirky wheel as we are doing now or actually financially joining the project. And in which way; investing in the company, usually we only invest in land or buildings. We do not invest in companies. The way in which we put our money into this, which revenues we will get out of it I do not know yet.

But the principle really interests me. I just not sure what our role will be. And as I said OMU as an investor into a company or in the actual deployment or maintenance – usually we do not do that. If we put some money into a project it is usually just to buy or improve land, a site or a building and not a long term relationship into X-Decks for the full 10-15years. So that is still a bit of an issue that we need to resolve. We have not talked about it at all by now.

There are also other locations in the province of Utrecht but it is still so vague. In other locations we could possibly buy the land in an area where a lot of things are happening. While all these developments are happening we buy the land and make sure there is an X-Decks for 3-5years after that, once it is no longer necessary, because everything is being developed, we remove the X-Decks and then sell the land to make sure that the enhancement of value increase and the added value of the land goes back to OMU, possibly to RHDHV – that has to be agreed upon. It is an interesting business case for us.

At the area mentioned before in Utrecht it is much more difficult because the land is already completely sold to professional large scale parties, who exactly know what will happen and what they want to do and how many houses they want to build. Nothing has happened there yet, they are making a master plan, designing projects. How much for who and how many houses per square meter and it is basically not what but how? So how will we make this work? Because it will be very innovative with an average car parking space of 0.2 per dwelling, basically nothing. Here they will be using the concept of MAAS (MobilityAsAService). You buy or you rent a house with a subscription and during every single day of the week you can choose if you use your subscription for public transport or an E-bike or for a little VW E-UP for a bit more money a Tesla. Depending on your mobility use and demands are for a particular day. Every day you can choose. And all these vehicles and services are available for the 5000 dwellings. This will be a very big change because the surrounding neighbourhoods are actually in fear because these are planned very traditional. There is still on the street car parking.

So how do you make sure that this land this land with a traditional surrounding does not got invaded by people from the new quarter who just buy a car and park it there. So the how question is what everybody is thinking about. And this is why we try to pitch the X-Decks here. So what will probably is that they start at 0.7 car parking per dwelling in 2018 because first houses will be finished in 2019/2020 and then by 2025 it will be decreased to 0.2 and how to do this – here you can use the X-Decks. You start off with a hub of 200 cars and then when you move it to the next spot then you provide 150 and then 100, 50…and when everything is finished you do not need it anymore. That is the idea; a smooth transfer. I am really keen about the project.
We do not know yet if the private stakeholders or the municipality will be excited as well and if they are excited we do not know which role OMU will have here.
Our role is to enhance work locations and in every session or brainstorm they organize [developers/municipality] we sit there and at the end we raise our finger and say listen; all this 5000 people have to work somewhere and right now this is still zoned industrial. There should be office

buildings, 1000 houses and a bit of working but primarily a residential area. Where do you think all these people will work? And how will they get there? And nobody knows. That is why the X-Decks system is so interesting. It buys you flexibility for a period of 5-10years. In the meantime you have this affordable hub and if it does not work you can move it to next site. So the concept I am really keen about. The role of OMU we do not know yet. At the end of January we will talk to the city and to the owners. We will do that with the business innovation from RHDHV and an engineer. So we pitch the idea and it will show if they are keen to close contracts with the land owners and investors. And then we can see what OMU can do.

I: What do you think about the proposed processes in the presentation? –you cannot discover your role in there yet…

S: Yes and because of the rules. Our company was founded by the province with a very clear task. A few times per year we have to check with the governor of the province what we have been doing, how we managed our investment of 15 million Euro. We have to explain what we have been doing with the fund. How much revenues we had and how much we spend. How many square meters we have improved or transformed. And this is very interesting because it does not tick all the boxes. Everybody thinks that if the X-Decks would work it will be amazing but it does not fit into our usual scope of work.

Long term commitment is government policy but our role is to stimulate and that is usually by short term engagement. So get the money back it short time. Every year our expenses are about 800.000 Euros and our income is about 600.000Euros. So every year we make a bit of a loss and that is basically renting costs, employee costs, project costs which we do not earn back. The 100.000 that we do earn is ROI either interest rates on loans or a value increase of land or a building. So we do not make a profit but we have to make sure that our loses are not that high either because our investment fund decreases. And that is what we have to tell the province a couple of times per year; how it is going. And in X-Decks it is interesting because if we go in there in there for the long term – the money is put away for 10 years and that is not what we usually do.

We started off with 15 million Euros, we made a slow decrease the last few years. OMU was created on a 10year scope and we have 13 million Euros left at the moment and we are half way to ten years. This is what we have – our assets, our liquidity. The money we have in the bank is lot more less then this because it all has been put into projects but it is all revolving. So if we put 2mEuros into this project for 5 or 10 years that means that it is 2million that we cannot use for other projects and the interest or revenue is interesting but it will be never 2million Euros. Possibly at the end but in the mean time we do not have the 2million. That is why we prefer short term engagement. Only 1, 1.5 or 2 million max for one project and 1, 1.5, 2 years of investment time and then it comes back with a bit of a revenue and then we can use that money for a different project. At the moment we have 5 or 6 million outstanding so we have about the same amount at the bank. But e.g. one year ago we only had 300.000Euros in the bank. The rest was all in projects. So when at that point in time, exactly one year ago, someone would have had come to us and said; I need one million to buy a building ,we would have said no because we did not had that money! We need the money back quickly to invest it again. So that is the thing; an investor things long term and we think short term. The big difference between us and regular investors.

I: …in some cases the municipality owns already the land.

S: Then they do not need us. From the two models that I drew up the second (no parties concretely involved yet.) one fits us most. The city or other stakeholders are listening; we need something to happen here that fits with our policy. Either by our own initiative; we buy this land or we are asked to

buy this land or we finance trusted parties to buy this land so that something happens where we all think that it is right and then we hope this is sort of a spin-off for the developments to go in the right direction. This really fits in with OMU. The first option in Utrecht is a lot more difficult because the land is already owned with a lot more prerequisites. And there is power and money. And usually what we say is that if things are going so well already here, we are not needed. We are needed for the 'crap' – in the really horrible and bad areas where nothing is happening or the wrong things are happening, or it is going down the drain. The second option is more our thing. And the first option in Utrecht where I will pitch the X-Decks it is more difficult for us because we have to think about how to interact between the different stakeholders.

One of the outcomes in January might be; one owner says great I need you next month and they sign a contract together and OMU does not do anything. Fine. If they work out something together we are fine with that. And what blockchain could do there I do not know. I understand the logics and also the logics for RHDHV but what is one of the first questions I asked Teun; I come from the biggest competitor here in Holland - Arcadis. And Arcadis was also struggling with their role – they wanted to get out of the 'uurtje fractuurtje' hourly paid services. They wanted to become a more trusted advisor and to participate in projects but without taking the financial risks of e.g. land ownership and how can we play a role in the chain finding our business – I think that is a good idea to formalize that in a blockchain. Dividing the roles and responsibilities between the partners in the chain – I think it is perfect. You take out the hierarchy. I was already looking is the advisor/consultant/project manager in the organigram? So this principle I understand but I do not know where OMU will join in in the chain.

The biggest if/threat is the long term perspective. A long term engagement of more than 5 years will be very difficult! That is the biggest threat for OMU in the blockchain. IT is really design, build, construct, maintain, operate the whole flow and lifecycle then it is probably not for us. When something is up and running we get our money back, with a bit of revenue and off we go – good luck guys.

The second option is really the perfect solution – you do not really know what is happening here, you buy this land and within 2,3 or 5 years, you have something there and also the other parties in the blockchain have an immediate cash flow. If it can be positive within 2-3years, when you consider the circularity aspect it actually generates money" and retains its residual value. So that means we could make within this 2-3 years a real difference. So the 2nd option is at this point in time more interesting for us. Only in the province of Utrecht we are not really talking to anybody about this concept. We are just talking with city of Utrecht so that is the situation we are currently in.

In the first option might be interesting for the developers to buy themselves in through a monthly fee so that the operator makes enough return on the investment in 5-10years and in the meantime it can be replaced, or scaled down within this 3-5years. What I understood is that is made for to be dissembled and adjusted. That makes it really interesting. In the meantime there is a fixed fee paid per dwelling or per square meter of land.

I: In the first option the developer is still strongly involved so they would decide if X-Decks is interesting or not.

S: Yes you still need a central party here – the spider in the web to really make it happen. We will not be the spider in the web. We can be one of the facilitators. And if the operator is RHDHV or 'Smart Solutions' or someone else, but you still need an operator.

I: It is interesting to see what could already work project related and what has to be refined in the future.

S: Barriers are primarily time and land.

I: Are there any other possibilities you see?

S: What makes it interesting is that is not a static project. Things change all the time for better or worse and it could make the blockchain interesting, of course there are risks involved. Each moment of time the stakeholders can be involved and can see what is happening. If the system works and there are always people behind the system, but if it works the possibilities for bad surprises are smaller.

I: At the core of blockchain is to cooperate, to create more transparency and trust and bringing parties together that were previously competing.

Do you have any additional remarks, comments…

S: I hope I could help you little bit as well. For the circular system, I think, it could work really well. Only for us, in our role, we do stimulate circular developments, through zoning, regulations, policies, sharing knowledge but our own role ,and I realize this through our talk even more, is really for the short term. To get things going, lighting the spark, greasing the wheel that is what we do and once things are up and running we back put and say good luck. I am curious as and wheater we can help out, so it has been also good for me to.

I: Can I use your name, project names and this interview for my thesis publication?

S: Yes.

The GIS map:

S: Not everybody can use it. It is really handy. Office related, industrial related. We have every building in the province of Utrecht with a commercial, office or industrial zone we have it loaded in the database. So we know about every building when it was build, how big it is, how many people work there. Which is really useful when you get a big office building with only ten people working there, then you know there is vacancy.

I: Where do the numbers come from?

S: It is updated 2x per year by the province. We get this data from the province. This is one of the reasons we cannot make it available for everybody. Sometimes it is paid for, sometimes there is a copyright.

It is very handy for us so we can see who works where. And especially large building with only a few people working there. We also know the energy label, an office needs between now and 5 years an energy label C. We know if long-distance heating can be used and if the gas company will change the underlying gas system and that means you can change it to all electric. So we can calculate how many vehicles have to be charged there, how many solar panels can be installed. Then there is the Solar Atlas commissioned by the municipality of Utrecht so they calculate the service area of roof, orientation of roofs, they have a construction of every roof/building. And we see ownership.

Some areas everybody knows in Utrecht but other industrial areas nobody knows about, the hidden ‘crap’ that is where we get very active.

We have the hard data and the soft data in the GIS, the hard data are the zoning plans, land-use…

And the sites we are working on…pipeline buildings, where we can or could be doing something. This is what we have for the whole province of Utrecht.

We also have a database with vacancy. You can see hotspots – where people really work. Papendorp is waiting to be developed. The pressure on the residential market is really high.

How evaluation of buildings is currently done is not transparent. In the office market it is a bit more transparent than it used to be but the really big industrial estates nobody knows what is happening here. If there is hidden vacancy or hidden use. You do not know what is happening behind the facade. An office building owner or user cares what the building looks like – it is their public address.

Old headquarter of gettronics – taken over by kpn. We financed a small developer to change this ugly building for a new tenant. We made sure that everything is reused. 4-6years ago. Big success. Old building tuned into a modern fit. The data was not collected what is in there material wise.

Sometimes this is a bit of a shame – our projects are in the areas where no one really cares about. But I like the fact that we fulfil a societal task and we do this task with commercial instincts, we do not subsidise but work market conform.

---------- (End of interview) ----------

Transcription Interview #5_ Bas Meeuwissen (Manufacturer)

Confidential

Transcription Interview #6_ Kevin de Lange, Douwe van den Wall Bake (Contractor)

---------- (Start of interview) ----------

Douwe: I work at a mother company of TBI. There we are always looking at what could be new on the horizon. From that point of view we are also looking into blockchain, AI…but the question is always how to make the magic between all the developments that are going on. Sometimes it sounds like a different world and then there is our existing world. So yes we know there are new technologies which are rapidly expanding and creating new markets but at the other hand in our business there was little change in the last two to three years. From this point of view things were changing somewhere else but we are still doing this. I am always looking at the moment when these worlds maybe come together. We talked about X-Decks earlier already and the blockchain application on that is worthwhile and we are also very open about the opportunities in there.

I: In which stage of the X-Decks project have you been involved?

Douwe: In the validation, checking the market and also the X-Decks concept.

Teun (RHDHV): I am part of the Smart Solutions Team of Royal Haskoning, a group of 15 people who are working on new business models. So we are working on scalable products instead of hours that is a new way of doing business for us. Last year I focused on X-Decks and Fastlane, a platform for energy transition in the build environment and the platform is going a bit faster than I thought so I am fully focusing on that but I am still involved in the blockchain part of X-Decks. The X-Decks concepts started eight years ago. The name used to be Park4All. A flexible parking system in Purmereend and two other places. It is an interesting concepts easy to assemble but it was not that easy to get it for a short-term period. We saw that many more clients would like to have a flexible parking solution. They have the demand but not really have the horizon to build a concrete garage so they were looking for short term solutions but the business case was not really easy to get it under a period of three years of rent. So we said it has to be better and we started to look at new ways to do due diligence and smart concepts. So I will not cover the technical part now. One aspect of making it smarter was also to look at current paper-use models with our suppliers to look at their lease models and the their approaches to circular economy and as part of that way we also got involved in blockchain to see if we can get a system where we can make a more collective business case with our suppliers in a so called “benefit sharing model”. So that we are not buying the materials and selling the garage as one product but renting it. Let me explain the concept with an example; you and me are paying per hour to park your car somewhere, currently there is QPark and they can rent the space for a certain cash flow per square meter per month. But to create this space you need building blocks that is why we are looking at a parking garage. It is relatively simple to start implementing a new model. You only need structure, floors and lighting. And of course you can make it more complex like at an office if you put more services into it. But in fact it is a really “easy” building. Now we are talking to many suppliers like Metsä for the flooring, Brink…of course it can always change, we are still independent there. So we are looking at a model where we can create a direct link from the consumer with their car to e.g. leasing a floor from Metsä for X Euro per object per month. So that we create a really flexible system where Metsä can stay owner of the floors. If there is some need for a garage we will create one, so that it is really easy to build in one week and if there is no usage anymore we can take it away.

Kevin:
So Brink, Metsä, Philips… if they build a parking garage in a very short period of time, they will stay asset owners, or owners of their objects?

Teun: Yes that is what we would like to do. So for now we see two models. There is the buy and sell back model. It is much easier to buy floors and then buy it back but I think it is nicer to look at a model where we are really doing a lease model. That is the "Horizon three" how we call the new way. Benjamin is trying to creating a framework how this could work in other way as an alternative model. To explore a bit how it could work.

Douwe: So you are looking at a garage because it is easy?

Teun: Yes that is one of the intentions. And there was written a lot about blockchain but I think we should do it!

Douwe: Is there another project you know that is more or less taking place in this field?

Kevin: With lighting by Philips the leasing is happening. And there is a construction/floor sharing…

Teun: But there is no overarching concept yet. You see some experiments but it is not really scalable yet.

Douwe: But I doubt the scalability issue because in other industries, like airlines, shipping or Internet of Things it is already becoming normal but not so much with blockchain yet.
I am still very curious because blockchain is in my first opinion is not very valuable to us – so now it is coming to your research and expertise to help us a bit further.

Kevin: Of course I understand ideas about parking spaces for short-term, but what is your goal – do you think this is also possible for utility buildings like e.g. office buildings?

Teun: Yes I think we can create something like real estate as a service and X-Decks is a proof of a concept for **thinking about more service orientated buildings**. Not that you are making a building and selling it but that you create services, what you also see with sidewalklabs from google. The technical part they do not know but they are introducing a whole new model in real estate. I think this will be disruptive how they are looking at the business side. But we are looking at the business site and the value e.g. a building is sold for 1 million but you can also make it available for 10.000 per month and during 30 years you are adding services. So if you want your fridge filled up every day you can buy a service from google and they get another cash flow for thirty years not only a selling moment. I think this will be the more disruptive part of google. They will sell it is perhaps a bit low-prices but you will get hold on a new model and that is a way to use supplementary services. We are also looking at that kind of way – how we can create these models.

Kevin: I understand that part with building ownership – there it is working. But if you look at the parties who are building elements like floors, also what we are doing; constructing – we have to invest then in such a model?

Teun: Yes exactly. And this is also what I want to talk about today – which roles are available in there. For a contractor it would be probably in the coordinating part. We see a lot roles to play in there. Our role would be to set up the concept but there are many parties around us who are necessary to e.g. maintain the building.

Kevin: I can follow you so far. But what we as a contractor want of course is investing, build and get our money back. And to get out back as fast as possible because we need it to build again. And when you say it will remain my ownership like the construction and the floors **then this hinders our processes.**

Douwe: The other example that comes here along is OVG with The Edge. Normally they say we design, build and sell – the quicker the better. But now they are also looking at revenues through recurrent services in the service world.

Kevin: Are they doing it with their own money?

Douwe: For sure they have some investment models for that.

Teun: I think an interesting part is also that OMU as an investor from the province of Utrecht is part of the model. So money is not really the problem. It is more about getting a concept together that the parties believe in and want to be part of. We are more looking into how to create this concept. And one open topic is the contractor that is why we are here.

➔ **Presentation**

Teun: I think it is also of interest to discuss the whole value chain. Also how the current model with the contractor is and how it could be in the future – I think it is more an imagination but that is also what makes it interesting - how it could be.

Hierarchical model
Teun: Do you also recognize a black box mentality within the diagram?

Kevin: Do you mean by "black box mentality" that the contractor and the subcontractor have their own goals and business cases? – I think so too. But why is the lock around the developer and the contractor?

I: Because the developer and contractor enclose information like profit margins to pressure other parties even if the project is going well to maximize their own profit on costs of the others.

Douwe: Do you say they do it together or do they do it both separately?

I: Sometimes developer and investor is one party. But I see them more as intermediates in this process.

Kevin: From the perspective of the client we as a main contractor are always in front of the subcontractor. So the developer has his own profit goals. We have our own profit goals. There are whole different contracts between them. We do not have any insights into the developers' profits.

Teun: I agree they have a different business case. We thought more about separate entities who are between the investor and the suppliers. And we are looking if we can create a product with more a platform thinking. How can you create in between a more shared model. I agree that the developer and contractor are not the same.

Douwe: In the Netherlands there are a lot contractors who combine development due diligence with contracting. So there is a scenery between them.

Kevin: We also do that in couple of projects in that sense we can be one party in the organigram too. In 90% of our projects it is completely different.

I: Do you agree with the hypothesis that the contractual pressure rises downwards in the organigram and then profit margins increase upwards?

Kevin: Like I said I do not agree about the lock around developer and contractor. I do not see that in most cases. So 10% yes, 90% no. I see more a problem between the subcontractor and manufacturer because the subcontractor is really in the lead there. If you look at a façade and the subcontractor has a very good connection to the manufacturer of the glass, they buy a lot of glass from them so they are really integrated. They are even more integrated than the contractor with the subcontractor. So if there is a "lock" it is there. Again the manufacturer of the glass has his own profit goals. They can lower their price if they want to have more projects. So there is always a profit goal in there.

I: So the more complex the product the more powerful the subcontractor?

Kevin: Yes

Douwe: In that sense. **The profit margin is decreasing if you go back in the supply chain is not true.** So the manufacturer has normally has a good profit margin but also needs it because there is a lot of product development which has to go on so he has to invest in R&D. So this not really the case what is shown in the diagram.
The other one "contractual pressure" what do you mean with that?

I: That in tendering in the process parties usually compete for the lowest price and that creates pressure to underbid each other, subsequently quality is lowering and risk failure risk is increasing.

Kevin: It depends on the market. When we are in the crisis and the investor has all the power it might be true but now the building economy is going up, now we are not at the top yet but when it happens then the manufacturer is on top. So it depends on the economic situation.

Teun: We are also interested in the back to back contract. So where the contract starts.

Kevin: That is true. Lately, the last two to three years it is changing in the back to back. Then it depends on the right size of the profit margin. So if we go back to back risks go more down in the chain. Then they want a higher profit margin. So it also depends on how you contract your subcontractor.

Teun: Do you see frictions in the back to back system? Because towards the investor it is not really transparent. If they want to know which manufacturer is chosen and why – they might have a transparency issue, if it needs to be transparent that is also a question. Not everything has to be transparent. So is that an alternative model?

Kevin: Yes there is also a friction. Another friction. **You can make it transparent at least you can try to. But it is not something that you can plan upfront, it depends on the subcontractor or manufacturer.** There are some easy reasons; are they overloaded or not? Can the manufacturer produce enough glass or do they have another subcontractor who can do the job? So transparency is nice but I do not know if it can be predicted or made more transparent. For the basis these are very banal things. They do business with each and look where there are the cheapest prices and where it is more expensive and if those parties are not constantly working together but just because there is good price at the moment – I think more transparency would not really make a difference here.

Teun: When you look e.g. at Kuijpers who agree on a upfront defined price and these prices variate because they give a price guarantee and that might bring them into trouble to stay competitive when the market changes.

Kevin/Douwe: Yes that applies to all builders – these are the hardest times.

Teun: And I think it could also work in an alternative model.

Douwe: What kind of model do you mean? Between the stakeholders there are a lot of contracts who define the model and the guarantees which the developers asks from the contractor and the contractor put it through to the other ones and that makes every project unique. So there is always a unique developer who has a unique contractor and the contractor has unique subcontractors…
Sometimes there is no logical relation between them. Sometimes it is really irrational. A developer might get things done by a certain municipality because he has some other chain project there, things like that. It is not rational

Kevin: There is no real combination between things. If there is e.g. a critical price for steel – which might be important for a parking building then you can expect to add a bit to the price of the manufacturer. But it is not only about the steel but also about the labour, currently there is not enough. So there is not really a correlation between this.

Douwe: The model in my opinion is the contract. And there is a combination of contracts. So one project has a combination of 10, 20, 30 contracts which make it the model. So if you say we make it different with one contract for all parties at this moment in time – that can be a different model.

Teun: Interesting. So can you look at the model to create shared incentives? We also discussed with Delta developments and OVG already three years ago to create a model **where incentives in the supply chain are more or less the same** (to lower uncertainties/ups and downs). In these contracts there are also frictions because of the incentives. And that can be interesting, it is currently more of a dream but we can work on that dream, where you are more supporting each other.

➔ Presentation continues

Second scenario
Teun: I think you always need a coordinating party – I think it is an illusion that the coordinating party in the middle can be replaced. It can be made easier or more automated.
The projects are unique and we are thinking more of a product same like X-Technologies from OVG. You create an IPhone…

Kevin: You can build that situation on a network of a simple project then it is fine but you cannot do that for a complex building.

Teun: Why not?

Kevin: A company like RHDHV they always need a contractor like TBI when there is something going wrong they have the capacity to absorb.

Teun: You can also look at an ecosystem to have capacity or capacity as a middlemen instead of a system.

Kevin: But then you need an investor with knowledge about the building process. An investor has capacity too. Because when I look at the diagram then the investor is the only other person who has capacity. But they usually do not have the knowledge to build. It is the same with the other parties. I know those models; where you do not need a main contractor anymore, the party who just buys everything themselves…. And this can work in specific cases but then there is nobody who gives guarantees when there is something going wrong on e.g. the technical site because these small parties do not have the capacity to carry that risk.

Douwe: Who do you have to give guarantees for the risk?
Kevin: The client wants it.
Douwe: But the client itself is part of it.
Kevin: But he does not want to take the risk.
Douwe: This is in the current model the case.
Kevin: Yes
Teun: The risk is lower.
Kevin: The risk sits then in the other parties.
Teun: So the system has to be so flexible and adjustable that if something goes wrong you can demolish the parking building in a week again.
Kevin: Yes with the parking space this might work but for an office building in Zuidas I cannot imagine that. To create ab manageable system with lower investment costs.
Douwe: But if the model could work that way. It is a thought experiments. It is also not new if you ask me. So the subcontractor is directly connected with the investor. In essence, the client and investor will always push the liabilities to the contractor…
Just from another point of view when you forget how it works right now. If you say a project is very, very, very complex then we cannot rely on paper based contracts or subcontracting. It is too risky business then. From that point of view you can say when something is very, very, very complex let us use very, very, very advanced technologies that help us to manage it. Because it is too difficult to manage for humans. And if humans stop managing very, very, very complex things then they will start managing their risk. So they will always do the best that they can to oversee that moment. This is just another way to think about it. And that does not mean that the contractor is out of the system because somehow I do not believe in that. It is also not the question right now.

Kevin: It does not matter, there will be always parties who are in the middle, intermediates.

Teun: Who is procuring the materials – that is the question. We believe that with that platform we can directly connect the investor with the procurement of materials. That is why we are not completely sure about the procurement role of the contractor, is that a big risk or a thing you (TBI) would like to do or could you focus on the assembly, coordination and logistics with higher margins? We are not sure if you are also interested in that?
The procurement is still vague for us – sometimes we do procurement ourselves. It is the so called "management supply 2.0" we are thinking of.

Kevin: I agree that it is steadily moving towards more collaboration and it does not matter with whom but it should be always be with one party that has a strong capacity. If something fails they need to capacity to keep the processes going otherwise everything collapses.

Teun: When the risks are lower then it is the question if you still need one strong party?

Kevin: When you keep your risks as a contractor and you have no securities for the people you contract the system does not work.

Teun: But there are initiatives from Delta or OMV who start to look for more collaborative approaches.

Douwe: But that is the classical thinking. When you start working with these parties. Just when you set up a smart contract there is nobody sitting in between. And you have a common contract that becomes mandatory and then you "outsource" capacity towards trust to the system.
When we do it in the currently common way we spend 100% and can we reach through the new model 80% of these expenses? The big question is can it optimize the overall process as an

integrated one? If you cannot manage it, you cannot manage the smart contract. Which one is the best model we can think about? If the collaborative model can automatize processes with smart contracts, higher reliability…then it might be better otherwise if the price is not better than in the classical model is still the best we can think of.

I: In the interview with Delta one key discussion was about the possibility to lower risks though a collaborative approach where a contractor opens the network of his subcontractors for a profit margin slightly above what is common in a classical model contracting model. With opening up the network real collaboration between the stakeholders can be stimulated instead of a race for lowest prices.

Douwe: Yes, of course from the 100% of spending 20% goes to risk management. Is this a logical model – no! But it is still the best we can think of for now.
So can we eliminate the costs for risk management in a different pattern? In terms of building materials, quality, lower price…one dimension we have not talked about yet is additional services. If you think about parking you do think about blockchain first, for an experiment of course but the whole building is simple. But if you talk about every time somebody gets into the building and GPS locates this person to get a bill and where he parked his car and used the garage 100 meters away then you pay people in a different way. Then contracts are becoming complex or smart.

Teun: And then services can be added to your garage; do you want your car to be washed, or deliveries put there, flowers…when you come back. That is what we are thinking of and then you want the smart contracts.

Douwe: Yes then is gets more complex. When you have e.g. a Chinese tourist who is once in the Netherlands who is using the services but then gets a bill to his home on China. That is the kind of system.

Kevin: I am thinking about if we as a contractor with our integrated business case – does this really work? Why should it not work? Because we all have different business models within our company. One part of TBI their business model is making more hours. The more hours they make the bigger the profit. In my department we do not do it by hours but by percentage. If you can make that visible and transparent in the blockchain then you can create a common incentive. Then we as TBI can offer more insights to the developer. Then the blockchain that is available and transparent for everybody. If you can make it work in that direction it is interesting for me.

I: So you see a high potential in merging the different business models within a contractor as well as the contractor with the subcontractor?

Kevin: Yes and what their win strategy/business model is, to make it manageable and transparent how parties earn their profits.

I: And why would you exclude the manufacturers and investors?

Kevin: We do not want to be locked to one manufacturer, we want to let the market work. Because it is not that easy to have one manufacturer constantly as the cheapest.

Teun: Same for us with the contractors. We do not want to be locked to one contractor. So it is about does he has the power to do it now or is he going back or not? There can be all kind of reasons not to work with a party at a certain moment. Maybe you have new innovations that is why you do not want to work with them anymore, they do not have the innovations…

Douwe: If you look at our ecosystem we are one shop with different flowers. We are a supplier, contractor…

(2nd scenario; explaining parties in the inner circle that are supposed to be bigger and long term interested, in the outer circle smaller and more flexible conditions can apply to the parties.)

Kevin: If you see the contractor in the middle you can still plug around whoever you want. But you do not have to put us as the main contractor in the middle but is just a contract.

Douwe: It does not matter which model you were thinking about by now. If you see an opportunity to use a transparent and shared model thinking to apply it, not for all parties you should focus on the contract itself. Because there you can create some extra profit already.

Kevin: You can see us as an example or also BAM. All the main contractors have this, all kind of different parties in-house. These parties would like to work together, they are family, but they have a different business models. If you can make them understand each other, then you can use incentives…

I: It might be good to do that on a project basis to create an example case.

Kevin: What we want as TBI is to see each other as a network organization, with different parties best for one project. In every project there is a different team so you have to understand what their goals are. If you can make that transparent then you can reduce the failure costs.

Teun: It would also make sense to have a **soft contract with clear parameters** when you choose a supplier and when not, where the budgets and lifetime are defined. And then there is a database that creates a shortlist of the suppliers who fulfil your criteria and then a smart contract you can automatically connect your supply chain. To create transparency and learn from each other. Then you ask the market and this is the new contract do you join?
We first want to start small. It is a thought experiment.

I: Explaining the third scenario. Connecting services to the end-user.

Kevin: Does it matter what you offer the costumer?

Teun: In the long-term X-Decks can be more business to consumer. And we(RHDHV) are still not doing enough on business to business towards investors. We(RHDHV) should more focus on that. It is already happening with smart buildings we are looking at the costumer journey, design thinking…so it is all starting. And I think a smart building is a whole different eco system than a current building. So this is on a long term perspective.
Another graduation student is looking at combining building assets and evaluation of buildings in the future. I think the evaluation models are also not correct anymore, they are outdated. So all these things will change, that is what is happening.
…
I think it would be awesome to make a Hyperledger network experiment within the building industry.
…
I think we want to explore this field before others will do it or will force us to do it. This research shall help us to make future predictions, before e.g. Google is doing it.

Douwe: Forget it, if Google comes along, they will come along! And if they have a winning model they win! Then just go home and forget about it.

I think if you want to be in here you have to do some serious experiments! And maybe you are lucky and you win.
I mean it does not mean you can do it too. It is also not like everything that Google is touching is a success. They fail in 90% of the cases as well.

I: ABN is doing the Torch project to improve their system for asset management in the real estate sector but we are the parties who have access to the data from the beginning of the building process and that is the data ABN needs to refine their models.

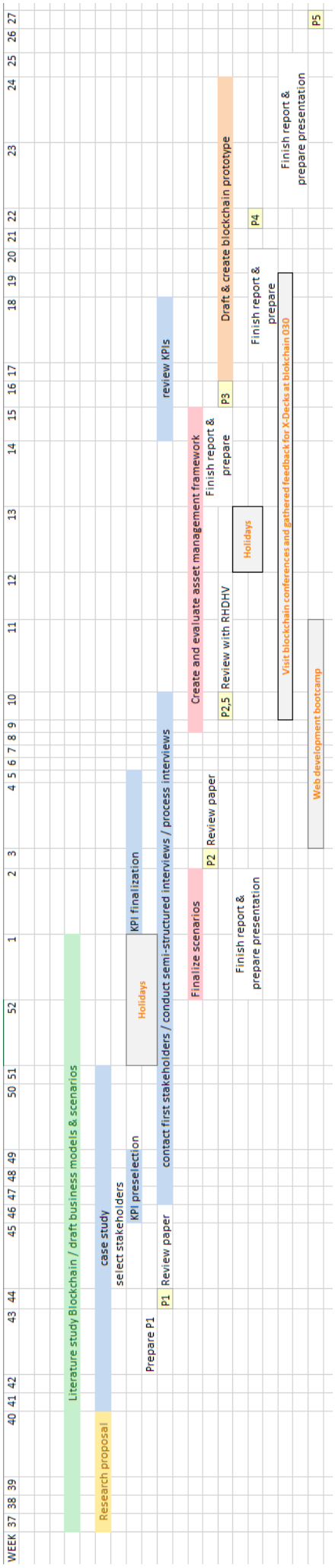
Teun: The goal should not be to disrupt but to transform the digital management on the chain that can be a use case.

Douwe: It can be very interesting already now.

Teun: Yes it is. Already in the short term.

---------- (end of interview) ----------

Appendix 7 – Research plan



Terugkoppeling & Next Steps

Park 4 All workshop 14 december 2016

"Circulariteit is niet alleen het behouden van grondstoffen, circulariteit is juist het behouden van de kwaliteit die je toevoegt aan die grondstoffen. Materialen mogen natuurlijk niet verloren gaan, maar dat is geen doel op zich. De waarde zit hem voornamelijk in de functionaliteit van dingen en niet in hun materiële samenstelling"

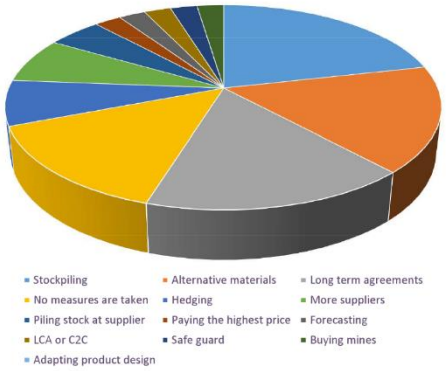
– Olaf Blaauw.

Inhoud

- We zijn ons allemaal bewust van de noodzaak van de circulaire economie
- Park4All 2.0 gaat voor een volledig circulaire aanpak
- Met mooie kansen op het gebied van samenwerking
- Hoe vertalen we deze kansen in de producten en de werkwijze?
- Naast kansen liggen er verschillende uitdagingen
- Hoe houden we rekening met uitdagingen in de producten en de werkwijze?
- De succesfactoren van de projecten
- Hoe borgen we succesfactoren in de producten en de werkwijze?
- De vervolgstappen zien er dan als volgt uit
- Vervolgstappen vertaald in de roadmap
- Vervolgstappen vertaald in concrete actiepunten incl. deadlines
- BIJLAGEN:
  - Contactgegevens deelnemers
  - Presentatieslides workshop d.d. 14 december 2016 (apart als .pdf bijgeleverd)

We zijn ons allemaal bewust van de noodzaak van de circulaire economie

- 97% van bedrijven denkt dat schaarste van materialen zichzelf oplost



Bron: David Peck, PhD (2016)

Park4All 2.0 gaat voor een volledig circulaire aanpak

- Park4All: we lossen uw parkeerprobleem op, i.p.v.: we bieden u een parkeerproduct
- Met hanteerbare delen en kleine elementen, zo min mogelijk fundering en zo weinig mogelijk impact op de omgeving
- Eindproduct is een esthetisch aantrekkelijk concept met maximale flexibiliteit in montage en demontage
- Weegfactoren:
  - 1. Economisch aantrekkelijk
  - 2. Optimaliseren op minimale leaseperiode
  - 3. Beleving/ ethische vrijheid – gevoel van veiligheid bieden
  - 4. Circulariteit/ functionele restwaarde
  - 5. Schaalbaarheid/ productie/ levertijd
- Voor een minimale periode van 6 maanden. Floriade 2020 is daarom een realistisch doel.
- Valley gebruiken als showcase om te experimenteren met het eerste concept

Met mooie kansen op het gebied van samenwerking

- De deelnemers aan de workshop willen graag aan de slag om echts iets concreets te gaan maken samen. De deelnemers voelen genoeg wederzijds vertrouwen om in een open setting met elkaar aan de slag te gaan en daarbij ook kritisch naar elkaar te zijn. De multilaterale aanpak werkt goed en Valley Creators speelt hierin een richtinggevende en faciliterende rol.

- Er is genoeg specialistische kennis en creatief vermogen aanwezig bij de verschillende partijen en hun netwerken om Park4All 2.0 te realiseren.

- De deelnemers zien dit project als een goede testcase voor opschaalmogelijkheden in andere markten, zoals sociale woningbouw. Het project wordt niet gezien als een doel op zich, maar als een middel om tot een circulair bouwsysteem te komen. Werken aan Park4All 2.0 wordt door de deelnemers gezien als een wezenlijke pilot voor circulaire productontwikkeling.

Hoe vertalen we deze kansen in de producten en de werkwijze?

KANSEN	Vertaald in producten:	Vertaald in werkwijze:
Vertrouwen om in open setting met elkaar aan de slag te gaan	• Paragraaf opnemen in LOI • Meenemen in design brief	• Manier van samenwerken deelnemers : open en kritisch • Richtinggevende en faciliterende rol Valley Creators
Inzetten kennis, creativiteit en netwerk van deelnemers	• Paragraaf opnemen in LOI • Meenemen in design brief	• Instelling van de deelnemers
Park4All wordt gezien als een wezenlijke pilot voor circulaire productontwikkeling	• Paragraaf opnemen in LOI • Meenemen in design brief	• Instelling van de deelnemers • Eindproduct niet zien als een doel an sich, maar als testcase voor het ontwikkelen van circulaire bouwsystemen in andere markten

Naast kansen liggen er verschillende uitdagingen

- Marktvalidatie parallel laten lopen aan het proces van productontwikkeling
- Het omgaan met IP binnen collaborative design: hoe staat IP ten opzichte van open innovatie?
- Goed nadenken over hoe het zich gaat terugverdienen voor alle deelnemers: wat is de collectieve businesscase?
- Verandering 'traditionele' cultuur bij slopers en handelaren
- Nadenken over demontage en transport
- Concurrentie ombouwen tot samenwerking
- Zijn er genoeg launching customers?
- Verschil eigendom van gronden met bijhorende belangen Valley (Delta, SADC)
- Rekening houden met Cradle 2 Cradle filosofie voor bouw in Valley
- Vergunningsaanvraag
- Moeten we een kermis- of steigerbouwer toevoegen aan het kernteam of slechts benaderen ter consultering?

Hoe houden we rekening met deze uitdagingen in de producten en de werkwijze?

UITDAGINGEN	Rekening houden in producten:	Rekening houden in werkwijze:
Marktvalidatie parallel laten lopen aan het proces van productontwikkeling	• Hoofdstuk over opnemen in high-level implementatieplan • Meenemen in planning	• Consulteren marktpartijen tijdens implementatiefase
Omgaan met IP binnen collaborative design	• Specifieke paragraaf in design brief opnemen over IP	• Voorstel valideren tijdens workshop
Hoe gaat het concept zich terugverdienen?	• Terugkomen als collectieve businesscase	• Aanzet tot collectieve businesscase ontwikkelen in workshop 2
Veranderen traditionele cultuur slopers en handelaren	• Meenemen in high-level implementatieplan	• Meenemen in stakeholdermanagement • Inspirerende voorbeelden creëren
Nadenken over demontage en transport	• Meenemen in design brief	• Voorstel valideren tijdens workshop
Concurrentie ombouwen tot samenwerking	• Opnemen paragraaf in LOI	• Inclusief denken
Zijn er genoeg launching customers?	• Meenemen in high-level marktonderzoek	• Valley als eerste launching customer
Eigendom gronden en belangen Valley	• Paragraaf in LOI	• Aanhaken van SADC in proces
Cradle 2 Cradle filosofie meenemen in testcase Valley	• Meenemen in design brief	
Vergunningsaanvraag	• Meenemen in design brief • Meenemen in planning	• Rol voor Delta Development Group
Kermis- of steigerbouwer aanhaken?	• Rol beschrijven in high-level implementatieplan • Meenemen in planning	• Bepalen tijdens tweede workshop

De succesfactoren van het project

- Voorwaarden tot deelname duidelijk voor iedere deelnemer, incl. de benodigde tijd / informatie voor intern commitment
- Design voor eindproduct in vroeg stadium duidelijk krijgen
- Vasthouden van momentum (in actiemodus blijven)
- Aanwezigheid van een collectieve businesscase
- Duidelijke verdeling van taken, rollen, functies en randvoorwaarden in open innovatie setting
- Een pilotcase om te experimenteren
- Regio als bindende factor
- Aanwezigheid launching customer(s)
- Definiëren van het referentieproject
- Aanhaken van fondsen

Hoe borgen we succesfactoren in producten en de werkwijze?

SUCCESFACTOREN	Borgen in producten:	Borgen in werkwijze:
Voorwaarden tot deelname duidelijk voor iedere deelnemer	• Vastleggen in LOI's met deelnemers	• Voorwaarden tot deelname afzonderlijk afstemmen met deelnemers in aanloop (januari) naar tweede workshop
Design voor eindproduct in vroeg stadium duidelijk krijgen	• Voorlopig design en/of prototype	• Prototyping
Vasthouden van momentum (in actiemodus blijven)		• Valley als procesbegeleider • Korte, regelmatige feedback momenten
Aanwezigheid van een collectieve businesscase	• Opnemen als hoofdstuk in high-level implementatieplan	• Ontwikkelen tijdens tweede workshop
Duidelijke verdeling van taken, rollen, functies en randvoorwaarden in open innovatie setting	• Opnemen in high-level implementatieplan	• Invulling geven door projectmanagement
Een pilotcase om te experimenteren (definiëren referentieproject)	• Vastleggen in LOI	• Valley wordt gebruikt als referentieproject om te experimenteren met het bouwen van het Park4All 2.0 concept (living lab). Een experimenteervergunning wordt hiervoor beschikbaar gemaakt.
Regio als bindende factor	• Opnemen in high-level implementatieplan	• Kijken hoe regionale stakeholders kunnen aanhaken (rol Valley Creators)
Aanwezigheid launching customer(s)	• Opnemen in LOI	• Heeft te maken met mindset van deelnemers: niet alleen Delta Development Group is launching customer. Alle betrokken stakeholders in onderlinge samenhang zijn launching customers. Dit vergt een nieuwe manier van denken, namelijk systeemdenken.
Aanhaken van fondsen	• Opnemen in high-level implementatieplan	• Kijken naar mogelijkheden in fase marktonderzoek

De vervolgstappen zien er dan als volgt uit:

1. Individueel contacteren deelnemers om voorwaarden tot deelname helder te krijgen
2. Aanhaken resterende deelnemers (Tata Steel, NPSP, Ikea)
3. Design brief opstellen
4. Workshop om tot overeenstemming te komen tot het ontwikkeltraject van Park4All 2.0, met als uitkomsten:
    - Designbrief valideren
    - Rolbeschrijving deelnemers kernteam en andere stakeholders
    - Aanzet tot collectieve businesscase
    - Intentieverklaringen tot deelname ontwikkeltraject
5. Opleveren high-level implementatieplan met aandacht voor:
    - Invulling project- en procesmanagement:
        - Rol- en taakverdeling
        - Sub teams rondom thema's
        - Planning en deliverables
    - Collectieve businesscase
6. High-level marktonderzoek
    - Overzicht marktkansen
    - Saleslijst met onderverdeling in leads, prospects & launching customers